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Astronomy

Examining Your Environment

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Astronomy

Examining Your Environment

John C. MacBean
Adam Stecher
Daniel F. Wentworth
J. Kenneth Couchman

Holt, Rinehart and Winston of Canada, Limited
Toronto

John C. MacBean
Social and Environmental Studies Consultant
Niagara South Board of Education
Port Colborne, Ontario

Adam Stecher
Assistant Superintendent
Perth County Board of Education
Stratford, Ontario

Daniel F. Wentworth
Science Consultant
Hamilton Board of Education
Hamilton, Ontario

J. Kenneth Couchman
Co-ordinator of Programs, Junior Division
Hamilton-Wentworth Roman Catholic Separate
School Board
Hamilton, Ontario

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Introduction

Introduction

We want you to get involved with the universe! It would be simple enough to state that the moon is 390 000 km from the earth. But how is such information obtained? We hope that this book will point out how the secrets of the heavens can be uncovered. The study of astronomy can result in an understanding and an appreciation of your earth environment and your place in the universe.

This book has five chapters – *Where Am I?, Stars, Our Star – The Sun, The Moon,* and *All In The Family.* Chapter 1 is the launching pad for the rest of the book; therefore, it is essential that all the activities in this chapter be done before attempting any of the activites in the other chapters. The last four chapters can be done in total, or in part, as the reader wishes. If your interest lies with stars, do Chapters 1 and 2. If it is the moon you wish to investigate study Chapters 1 and 4. However, if you want to develop many skills and acquire knowledge of astronomy, all five chapters should be done in the order in which they are presented.

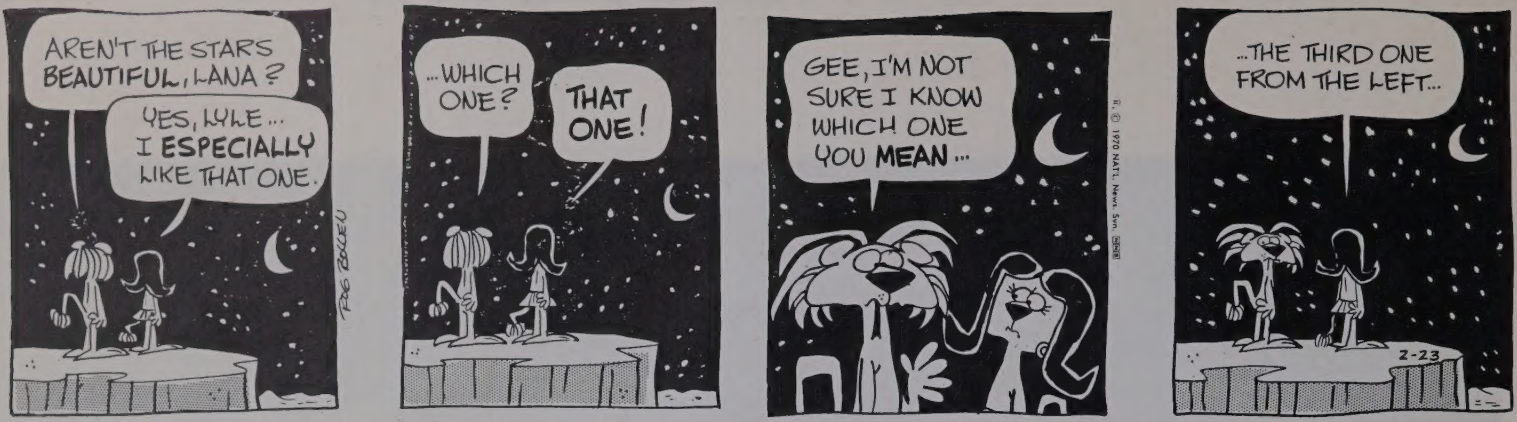
If you plan to work through the entire book, the star chart outlined in Chapter 2 should be constructed, and the skills associated with the star chart mastered as soon as possible. This chart will be helpful in many activities suggested in other parts of the book. The star chart is a most important tool for attaining a working knowledge of astromony.

An excellent bibliography is listed at the end of the book. The bibliography can be used to gain further understanding of the *Digging Deeper* and *Branching Out* sections which follow each activity.

Where Am I?

1

1. Where Am I?


AREN'T THE STARS BEAUTIFUL, LANA?
YES, LYLE... I ESPECIALLY LIKE THAT ONE.
REG BOLLEN
...WHICH ONE?
THAT ONE!
GEE, I'M NOT SURE I KNOW WHICH ONE YOU MEAN...
© 1970 NAT'L. News. Syn.
...THE THIRD ONE FROM THE LEFT...
2-23

We are all Lyles in a way, since most people who have not been trained in observing the sky encounter the same problem that Lyle is having with Lana. Lyle does not know to which star Lana is referring.

The activities presented in this chapter will help you realize where you are in the universe and give you a framework upon which you can build your skills and general knowledge in astronomy.

Activity 1:

Where are we?

To determine where we are in the universe, examine the following series of pictures.

Digging Deeper

Using the photographs as a guide, describe what happens as one goes outward from the earth.

Discuss the following statement with your classmates: ''We are but a speck of dust in a vast, black ocean.''

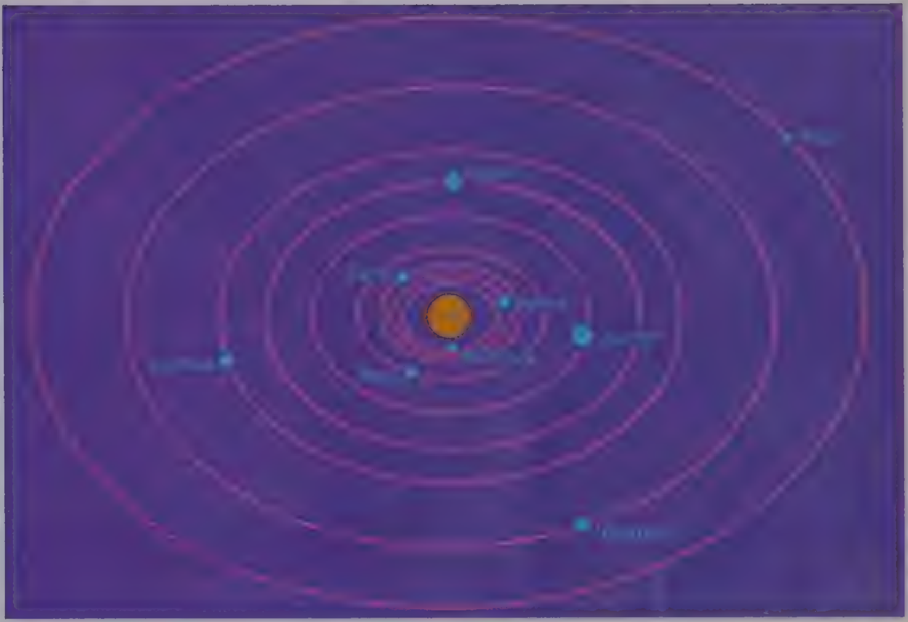
''Man lives on an island in-space.'' Do you agree or disagree with this statement? Explain your decision.

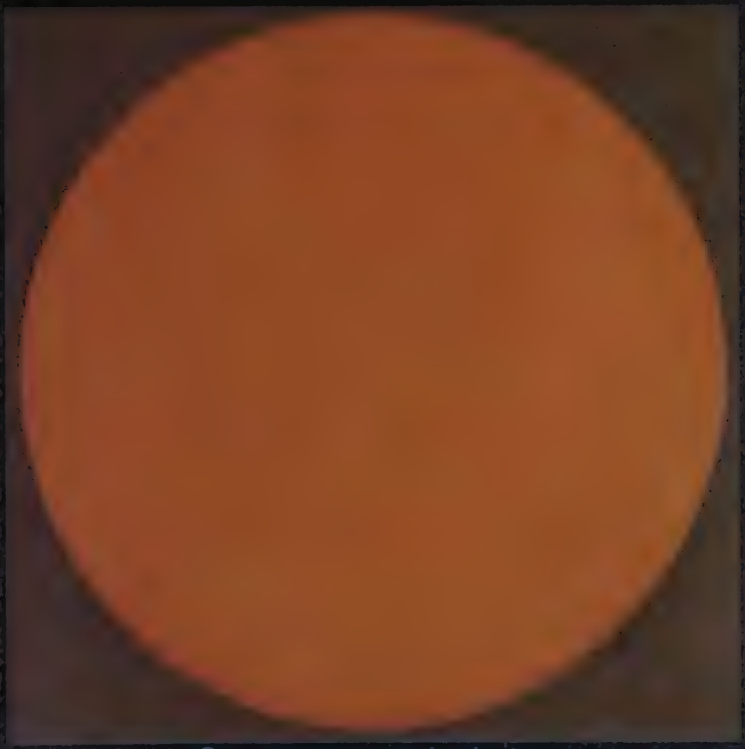
Astronomers feel very humble when they study and observe the universe. Why?

Does there seem to be any up, down, or sideways in the universe?

Does the universe seem to have limits?

These planets, as does the earth, belong in the sun's family.





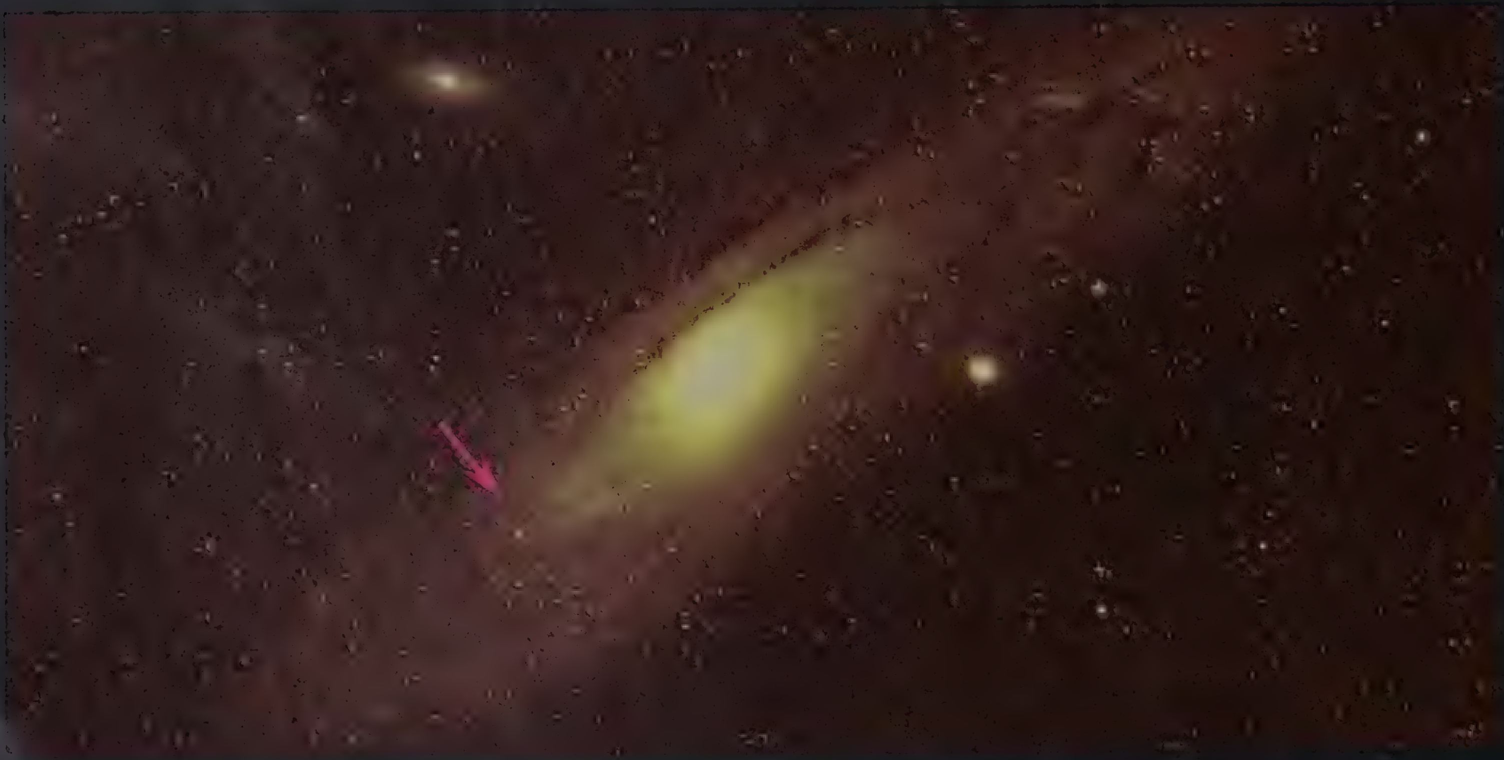
Our nearest star is the sun.

Our nearest sky neighbour is the moon.

Here are three other galaxies or "cities" of stars like our own.

The arrow points to the location of our solar system in our galaxy.

There are millions of galaxies in the universe.



Branching Out

HOW CAN A MODEL OF PART OF THE UNIVERSE BE MADE?

Using the chalkboard, draw a scale model of part of the universe. The scale will be 1 cm : 6500 km. Begin with the earth. Since the earth has a diameter of about 13 000 km, show the earth as a disc 2.0 cm in diameter. The moon can be shown as a 5 mm disc. What would be the distance in centimetres between the moon and the earth on the chalkboard? Hint: the distance from the earth to the moon is approximately 390 000 km.

Why would it be difficult to locate the sun on your chalkboard model?

Activity 2:

How can we establish a set of rules or a frame of reference for locating objects in the sky?

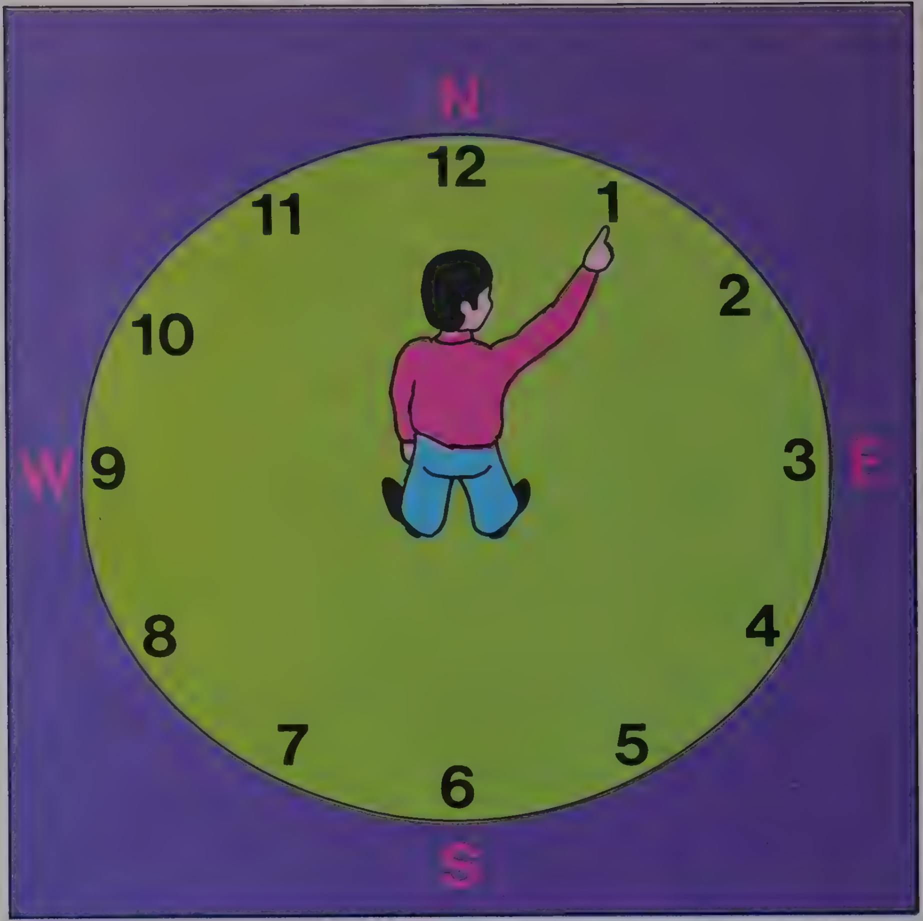
Suppose you saw an interesting star in the sky and you wanted a friend of yours who lived some distance away to observe it. How would you describe to him over the telephone, where to look in the sky so that you were certain that you were both looking at the same star? This would be very difficult to do unless you both had accepted the same set of rules by which to locate the star. A set of rules or *frame of reference* would simplify the problem.

For this activity a magnetic compass would be desirable since you must locate north, south, east, and west. If a compass is not available refer to the *Branching Out* section immediately following this activity. It outlines ways to find north without the aid of a compass.

Find an open, level piece of ground. Place your compass on the ground and wait until the needle stops swinging. Once the needle has come to rest, orient the compass by turning the compass housing until north on the compass housing is lined up with the north end of the needle. Have your teacher or another adult check the setting. Now identify the four directions: north, south, east, and west. Take your hand and make a sweeping motion over your head from the northern horizon to the southern horizon. Do the same from the eastern to the western horizon. What shape is the sky over your head? Why can you see only half of the sky? Where would you have to go to be able to view the other half?

Where is the center of the sky in relation to you? Point with your right hand

The compass must be oriented before taking a reading.



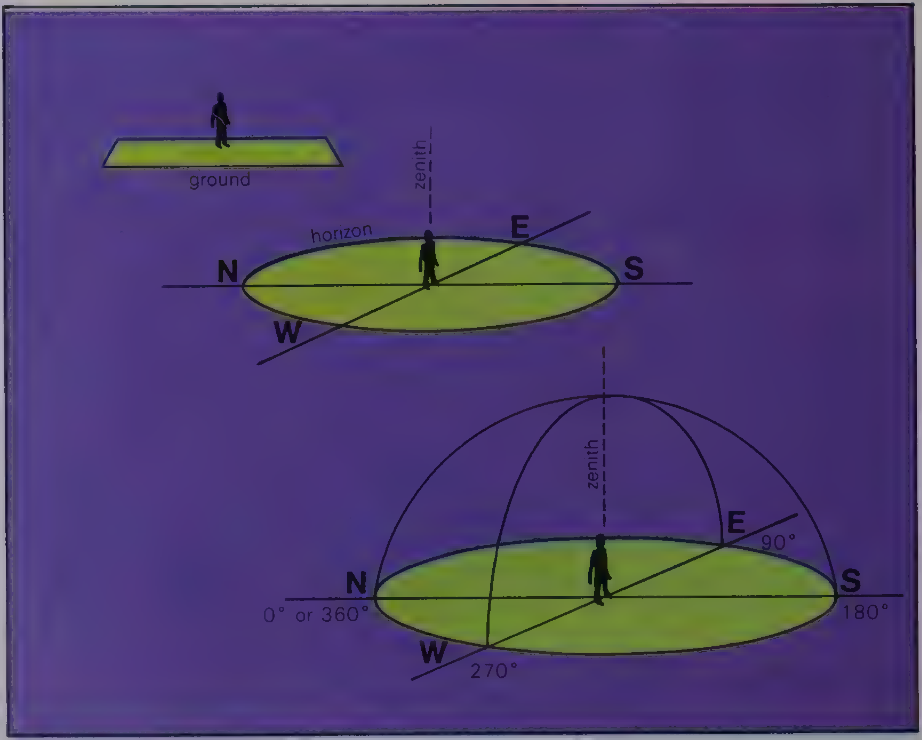
In what direction is the person in this clock facing?

toward north, and, turning clockwise, make one complete turn until your hand points toward north again. You have just made one complete circle. Let this circle represent the face of a clock lying flat on the ground.

Twelve o'clock will be north, three o'clock will be east, six o'clock will be south, and nine o'clock will be west. If you wanted to point to the direction southwest what time would be in that direction on the clock? If you were asked by a friend to face eleven o'clock, in what direction would you be facing? From now on, when you wish to refer to a direction relate it to time on a clock. Twelve o'clock will always be lined up with north and you will always be in the center of this imaginary clock.

Look at the point in the sky that is directly over your head. Do *not* look up with just your eyes. In order to do this properly you will have to lean your head back as far as possible and look up. The point directly over your head is called the *zenith*. All visible objects in the sky are found between some point on the horizon and the zenith. If we say the horizon is at 0° and the zenith at 90°, we can easily measure in degrees the location of objects above the horizon. If a star seems halfway between the horizon and the zenith we could say that it is at about 45°. However, estimates are not good enough and astronomers have developed, as you will see, an accurate method of locating objects in the sky.

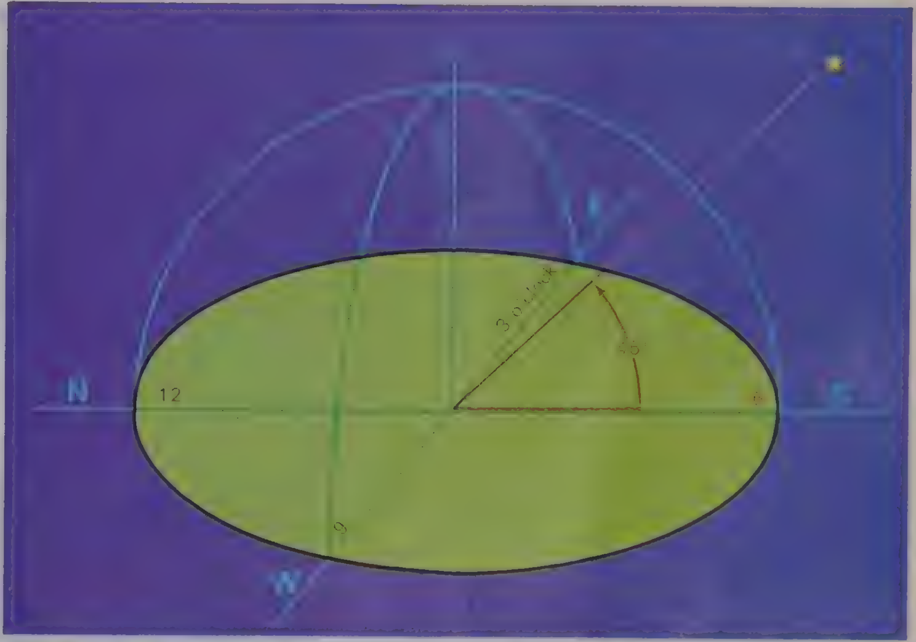
By combining our imaginary flat clock with the degrees between 0° and 90° it

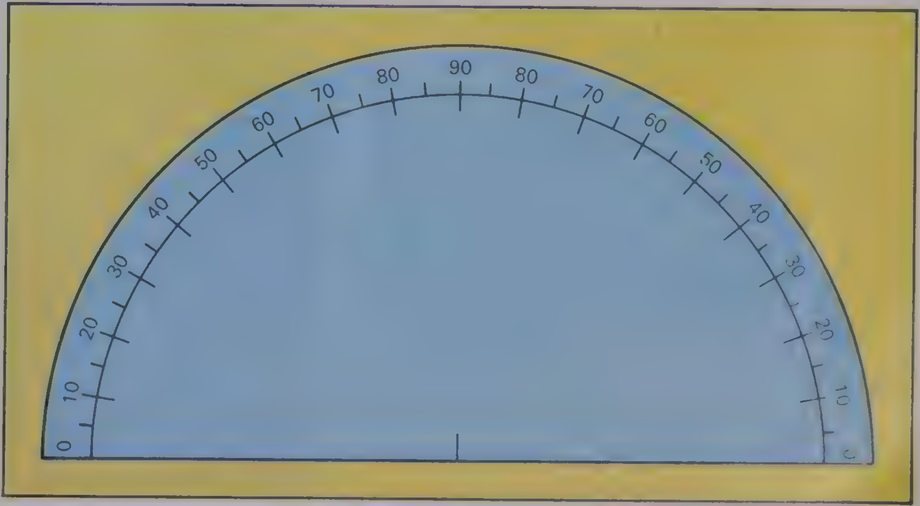


The zenith is the highest point in the sky directly above your head?

is an easy matter to give another person a frame of reference from which he can understand where you are looking. For example, suppose you were looking at a star in the southern sky about halfway between your zenith and the horizon. You could explain to another person where to look by giving him the directions or frame of reference: "six o'clock, 45°." If the person is familiar with the clock-and-angle method he would turn and face six o'clock (the southern horizon), then he would look up in the sky at an angle or elevation of 45° (halfway between the horizon and the zenith), and he would, hopefully, see the same star as you do.

This set of rules for locating objects in the sky is called the *azimuth-altitude method*. To use this method, first you give the direction, the *azimuth*, and then the elevation in the sky, the *altitude*. Azimuth comes from Arabic and means "the way or direction". Azimuth will be measured in degrees starting from north and going clockwise around our imaginary flat clock. Altitude is the measure of an object above the horizon, also in degrees. Look at the cartoon on page 2 again. Can you now solve Lyle's problem?





North will lie halfway between the shadow and the numeral 12 on the watch face.

Digging Deeper

What is the *horizon?*

What instrument is commonly used to measure angles or degrees?

What is meant by the words *clockwise* and *counterclockwise?*

What does the word *altitude* mean? *azimuth?*

What does the word *zenith* mean?

Branching Out

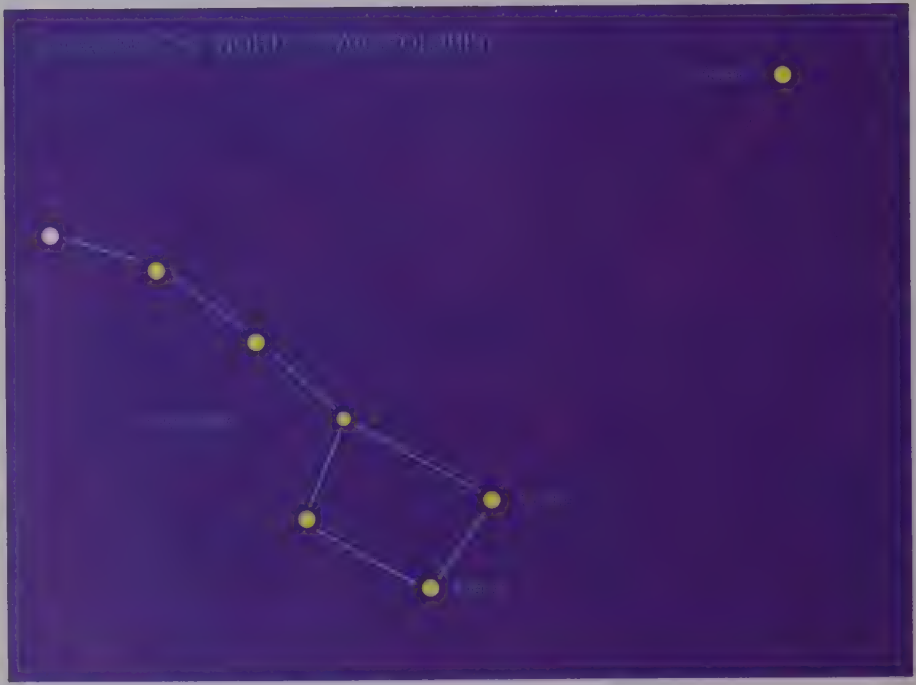
Describe, using the azimuth-altitude method, the location of the following: the sun at sunrise, sunset, and noon; the moon when you go to bed. Compare your answers with those of your classmates.

How can the direction north be found without using a compass?

On a sunny day, find north by placing a match, toothpick, or other thin stick straight up on its end, and over the center of a wrist watch. Turn the watch until the hour hand is lined up with the shadow cast by the stick. North will lie halfway between the shadow and the numeral 12 on the watch face.

True north can also be located at night by using the Big Dipper. The Big Dipper will always be found in the northern sky. Locate the two stars at the end of the Big Dipper's bowl. These can be used to find the North Star, *Polaris.* Imagine that a line connects the two end stars of the Dipper, and extends beyond the open end of the Dipper a distance five times the distance between the two stars. A star can be seen at this point with the unaided eye; it is called Polaris or the North Star. When you are facing the North Star, south will be at your back, east to your right, and west to your left.

If the distance between Merak and Dubhe is extended 5 times, the closest visible star that you would see is Polaris.



Activity 3:

How can an instrument for more accurate measurement of azimuth and altitude be made?

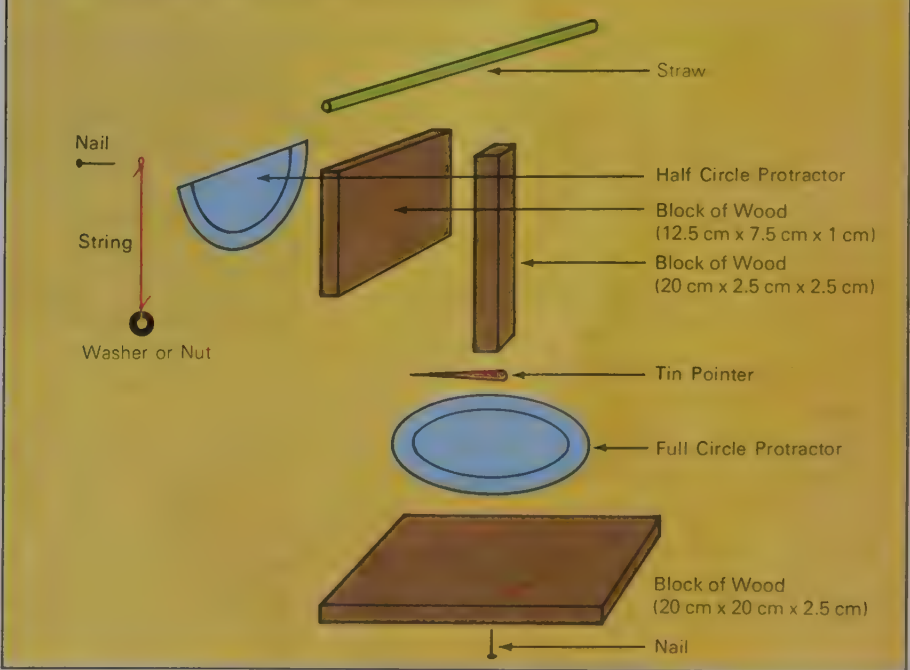
In order to become a skilful observer you must be able to locate objects in the sky much more precisely than just by giving a numeral on the face of a clock and by estimating an angle, in degrees, above the horizon. An *astrolabe* is an instrument that can give you the type of precision required when measuring stars in the sky. Since the horizon is a circle, it can be divided into 360°. Zero degrees will be at north, 90° at east, 180° at south, 270° at west, and 360° will be back at north. Therefore, north can be called either 360° or 0°.

As the sky over your head appears to be bowl-shaped it too can be divided into degrees, 0° being at any point on the horizon and 90° at the point directly overhead. Once the point directly overhead is reached and passed, you begin to move toward 0° again. Everything in the sky can be pinpointed by giving its position in degrees between the horizon and the zenith. This, of course, is the altitude of a star.

Make an astrolabe using the following directions.

a 12.5 cm x 7.5 cm x 1 cm block of wood;
a 20 cm x 20 cm x 25 cm block of wood;
a 20 cm x 2.5 cm x 2.5 cm piece of wood;
a pea shooter or milkshake straw;
a 15 cm piece of black thread;
a small metal washer;
a 1 cm by 7.5 cm piece of tin, (cut this from a tin can and taper one end to a sharp point);
a paper half-circle protractor;
a paper full-circle protractor;
a 5 cm nail;
a 4 cm nail;
a bottle of all-purpose glue.

EXPLODED SKETCH OF AN ASTROLABE


Straw
Nail
Half Circle Protractor
Block of Wood (12.5 cm x 7.5 cm x 1 cm)
String
Block of Wood (20 cm x 2.5 cm x 2.5 cm)
Washer or Nut
Tin Pointer
Full Circle Protractor
Block of Wood (20 cm x 20 cm x 2.5 cm)
Nail

To construct the astrolabe, examine the exploded sketch of the instrument and then follow these steps.

Trace both the half-circle and full-circle protractors.

Glue the half-circle protractor onto the 12.5 cm x 7.5 cm x 1 cm block of wood as illustrated in the sketch.

Glue the full-circle protractor onto the 20 cm x 20 cm x 2.5 cm piece of wood. To center the full-circle protractor correctly, draw lines on the block of wood from corner to corner making an X. Punch a hole in the center of the paper protractor and line it up with the center of the X on the piece of wood. This procedure can be called the X method.

Use two elastic bands to hold the pea shooter or straw on top of the 12.5 cm x 7.5 cm x 1 cm block of wood.

Glue the broad end of the tin pointer to one end of the 20 cm x 2.5 cm x 2.5 cm piece of wood

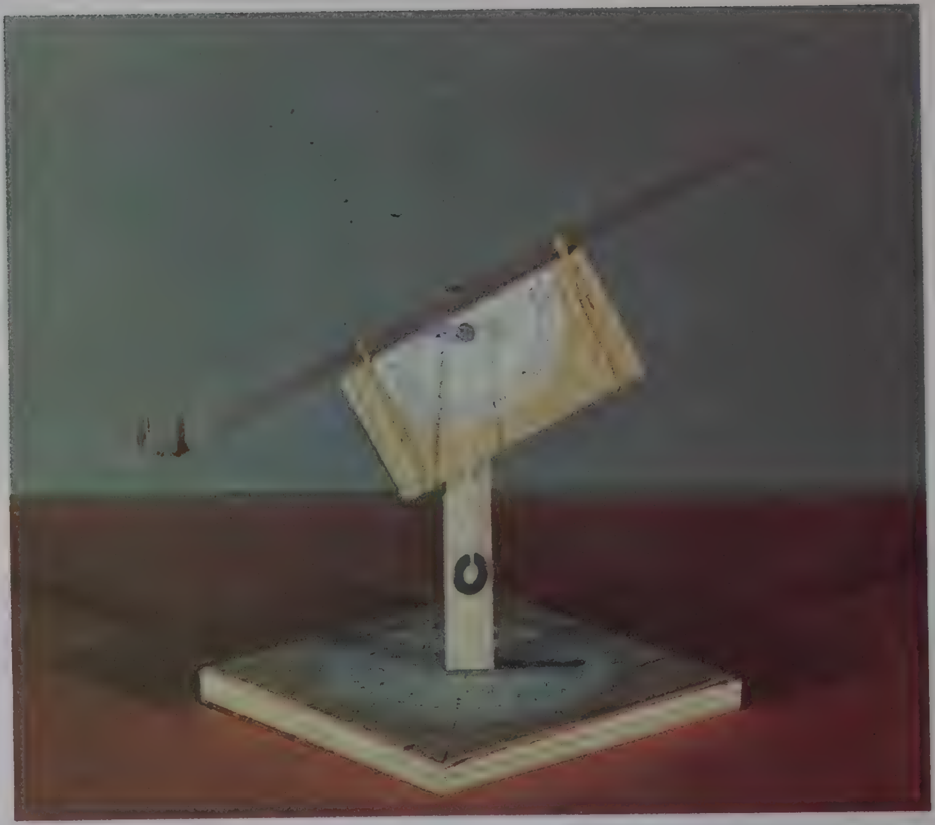
When the glue on the piece of tin has dried, take a nail and hammer and punch a hole through the tin and into the wood. Center the hole by using the X method.

Punching a hole in the tin will allow for easier assembly later.

Assemble your astrolabe by nailing the 12.5 cm x 7.5 cm x 1 cm block of wood near the top of the 20 cm x 2.5 cm x 2.5 cm piece of wood with the 4 cm nail. Hammer the nail directly through the part of the protractor labelled A. Leave part of the nail protruding so that the piece of thread can be tied on it.

Nail the 20 cm x 2.5 cm x 2.5 cm length of wood onto the 20 cm x 20 cm x 2.5 cm piece of wood. Center the nail on the 20 cm x 20 cm x 2.5 cm piece of wood using the X method.

Tie the metal washer to one end of the piece of thread and tie the other end of the thread to the nail hammered into point A on the half-circle protractor.



An assembled Astrolabe.

On a clear night take your astrolabe outside and place it on something level such as a table or cardboard box. Line up 0 on the full-circle protractor with true north. This can be done by sighting Polaris as described on page 8. Without moving the instrument from this *base* position, the top part of the device can be swung around clockwise until the desired object in the sky can be sighted through the pea shooter or straw. Once the sighting has been taken, the altitude can be obtained by reading the numeral directly behind the thread on the half-circle protractor. The azimuth can be obtained by reading the numeral directly at the end of the tin pointer on the large full-circle protractor. A small flashlight with its lens covered with red tissue paper or red cellophane will aid you in reading the astrolabe in the darkness of the night.

An astrolabe measures the azimuth and altitude of an object in the sky.

Digging Deeper

Why does the astrolabe locate objects in the sky more precisely than the clock method outlined in Activity 2?

Why must the astrolabe be level?

What tool is used to measure how level a surface is?

Why must the astrolabe be lined up with true north before using it?

What purpose is served by the red cover on the end of the flashlight?

How could you improve your astrolabe so that it wouldn't be necessary to find something to set the astrolabe on each time it is taken outside to use?

Branching Out

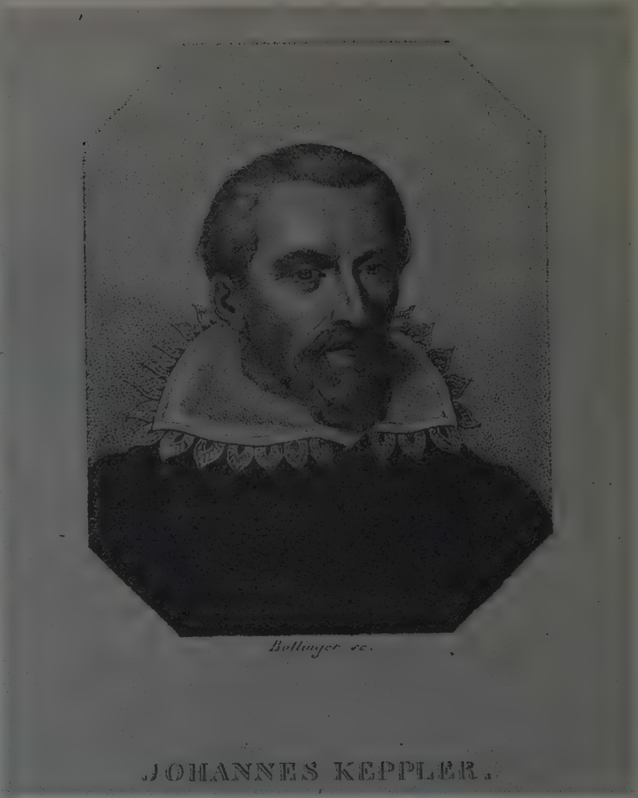
Latitude of an object on the earth's surface is the number of degrees it is from the earth's equator.

Find the latitude of your house. This can be done by sighting Polaris using your astrolabe. Observe the angle or number of degrees at which the thread crosses the half-circle protractor scale. This is the angle Polaris is above the horizon at the point of the observer (you), and is equal to your latitude north of the equator. How could you find your latitude if you lived in Australia in the southern hemisphere?

Check the position of Polaris above the horizon each night for one month, and observe whether it changes. Does the time you make your observation each night have any effect on your study?

The following men are considered to be giants in the field of astronomy: Aristarchus, Ptolemy, Copernicus, Galileo, Brahe, Kepler, and Newton. Use an encyclopedia to discover when each man lived and what each contributed to the science of astronomy.

SIR ISAAC NEWTON


Bollinger sc.
JOHANNES KEPPLER.

Stars

2

2. Stars

PEANUTS
DO YOU KNOW HOW MANY STARS THERE ARE IN THE SKY, LUCY?
4-18
OF COURSE! THREE HUNDRED AND SIXTY-FIVE... ONE FOR EACH DAY IN THE YEAR..
WE LIVE IN WHAT IS KNOWN AS AN ORDERLY UNIVERSE!
SCHULZ

From the beginning of time, man has looked up at the sky at night and wondered about the endless specks of light suspended above him. These specks of light man called stars. His fascination with them led him to believe that his fate was determined by their motion. "To wish upon a star", is a familiar expression.

Many songs, poems, and some of the myths of the early Greek and Roman civilizations have their origin in the positions and groupings of stars. To find their nature is an ageless quest. In this chapter you will see that the stars affect man's sentiments and fantasies.

When observing the sky for the first time, it is difficult to locate stars. This problem is compounded by the motion of the earth which presents us with an orderly parade of stars during every hour, of every night, of every year. Special pieces of equipment such as star charts have been invented to help in following the ever-changing picture formed by the heavenly bodies.

Activity 1:

What is a star-finder chart?

An important item in helping us to learn about the stars in the night sky is a *star-finder chart.* It is a road map of the sky. If you can master the skill of using a star-finder chart, you can locate the position of a star during any hour of the night on any night of the year. The star-finder chart provides this additional information: the name of the star; whether a star rises and sets; the constellation a star is in; the altitude of the star above the horizon; and the brightness of the star.

To assemble a star-finder chart for yourself, you will need to use the following materials:

the templates marked III and IV on pages 92 and 93;
a piece of heavy, stiff cardboard the same size as template III;
a paper rivet;
glue;
two pieces of black thread;
cellulose tape.

Trace both templates onto a piece of plain white paper.

Cut out the areas indicated by the broken lines on template III.

Cut out the circular star disc of template IV.

Fix template IV to the piece of heavy cardboard with the rivet. Use the X method to find the center of the cardboard.

Use a sharpened pencil point to punch a hole in both the center of template IV and the cardboard marked with the X.

Fix template III on top of template IV

Follow the directions carefully when assembling the star chart.

by its corners only, with glue, to the piece of cardboard. When you have finished, check to see that the circular star disc below it turns freely.

When the glue has dried attach the black thread to the star-finder chart by punching out the four red dots labelled N, S, E, and W. Join the N and S holes with one piece of thread; join the E and W holes with the other piece of thread.

Use tape to fasten the ends of the threads to the back of the cardboard. The threads represent imaginary lines in the sky going from horizon to horizon.

The crossing of the two threads marks the zenith. The threads can be used as a guide for pointing out a certain star. For example, you could say that a star is on the north-south thread and near the southern horizon, or near the zenith.

Commercial stars charts such as those pictured on page 16 are available from:

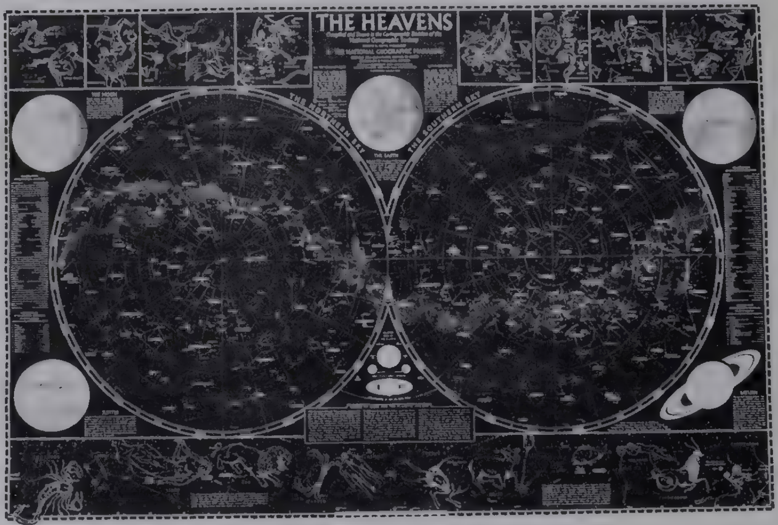
Moyer Vico Limited
25 Milvan Dr.
Weston, Ontario

Now that your star-finder chart is completed, what can you discover about it? Use your chart to help in answering the questions in the Digging Deeper section.

Digging Deeper

If you were to draw a picture of the stars in the sky, where would the center of your picture be?

Does the star-finder chart indicate time? Which side of the chart shows the sky in the morning? Which side shows the sky in the afternoon?



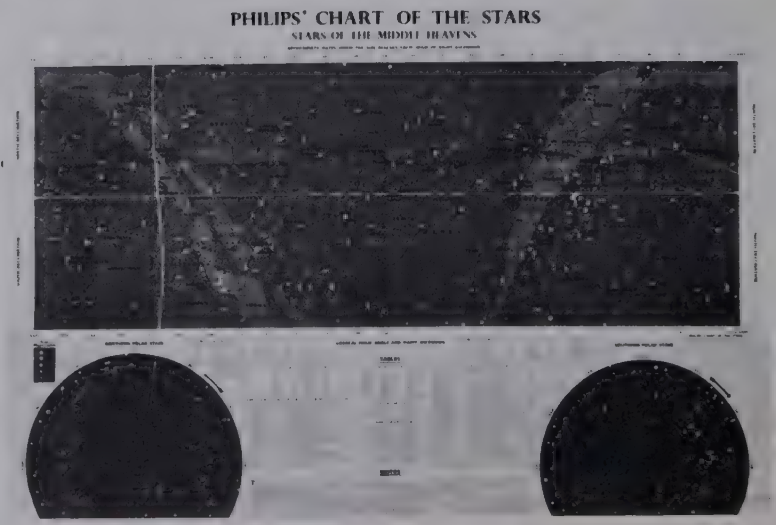
What directional markings are on the star-finder chart in addition to north? Place the chart face-up in front of you, with north on the chart pointing toward true north. Is the position of east on the chart the same as on a road map? In what way is your star-finder chart similar to a calendar? Are all the days of the month numbered? Is there a space for every day of the month?

What does the edge of the oval circle on the face of the star-finder chart represent?

What star does the paper rivet represent?

If the edge of the oval circle represents the horizon, what point is represented by the intersection of the two black threads?

Each night stars appear to rise in the east and travel in a westerly direction across the sky. When you turn your star-finder disc, should you turn it clockwise or counterclockwise in order to have the stars move correctly?



How are these Star Charts similar to the one you made?

Activity 2:

How can stars be located and identified using a star-finder chart?

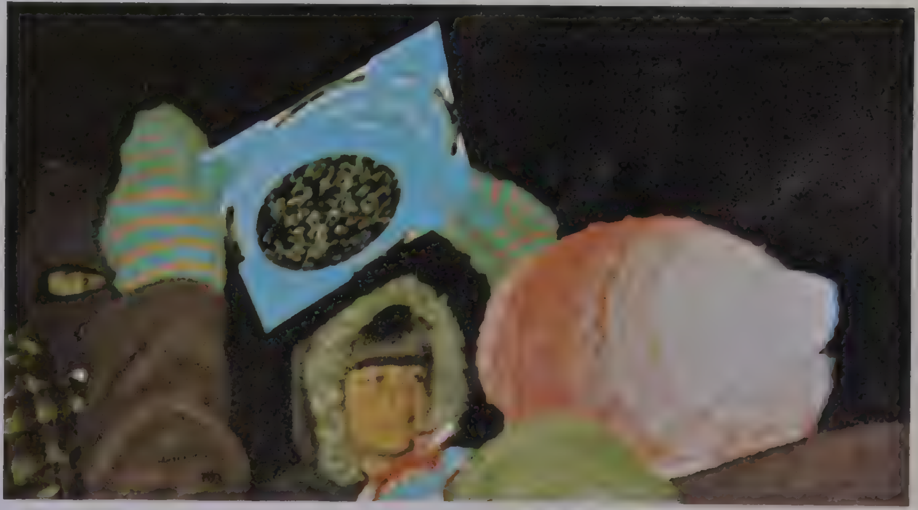
Your star-finder chart deals with the better known constellations which can be seen in the northern hemisphere during the year. The earth rotates once every 24 h and as a result we see a number of different stars pass overhead during the night. The earth also revolves around the sun once every 365 d, therefore we see different stars at different times of the year.

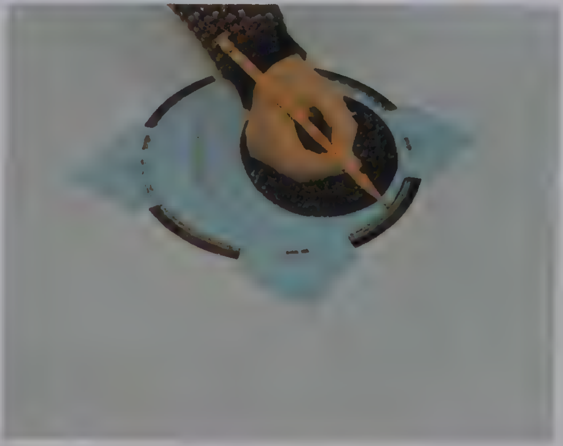
Each season displays its own special patterns of stars in the sky. These patterns or constellations can be used as a starting point to learn about the yearly parade of stars. When the chart is used out-of-doors, it must be held upside down and over your head. North on the star-finder chart must point to true north as shown in the photograph. With the star-finder chart held in this position, east takes its proper place on the right-hand side. Try it and see for yourself!

The part of the sky that can be observed at any one time is about the same as that shown in the oval that you cut out of the face of the chart. The edge of the oval represents the horizon or 0° altitude. The center of the oval, where the two threads cross, represents the zenith or 90° altitude. Therefore, when the start chart is held correctly over your head, you must imagine the sky as an upside-down bowl with the center directly over you.

To set the star chart for any given date you must look at both the hours marked on the face of the chart and the calendar around the outer edge of the star disc. Select, for example, 21:00. Turn the star disc until today's date is next to 21:00. The constellations in the oval section will be visible at 21:00 if the sky is clear.

The star-finder chart must be held over your head with north to north, south to south, and so on.





Digging Deeper

Why is the North Star (the paper rivet) not at the center of the visible sky on this chart?

Set your star chart for 21:00, September 1. Now locate the Big Dipper and watch it while you turn the star disc counterclockwise, one day at a time, to February 1. How is the Big Dipper moving in relation to the North Star? What is the North Star doing? Why doesn't the North Star appear to move? How are all the other stars moving in relation to the North Star? Why is man able to use the North Star to find direction?

Suppose you observe the stars at 21:00 on February 3. How long will it be before you can see the heavens in exactly the same position again?

Would this star chart work near the southern end of South America?

At what elevation above the horizon would you find the North Star if you were at the equator?

Are there any constellations on your star chart which never rise or set during an entire year?

Why can we not see all the stars in the daytime? Are there any stars visible around noon?

Activity 3:

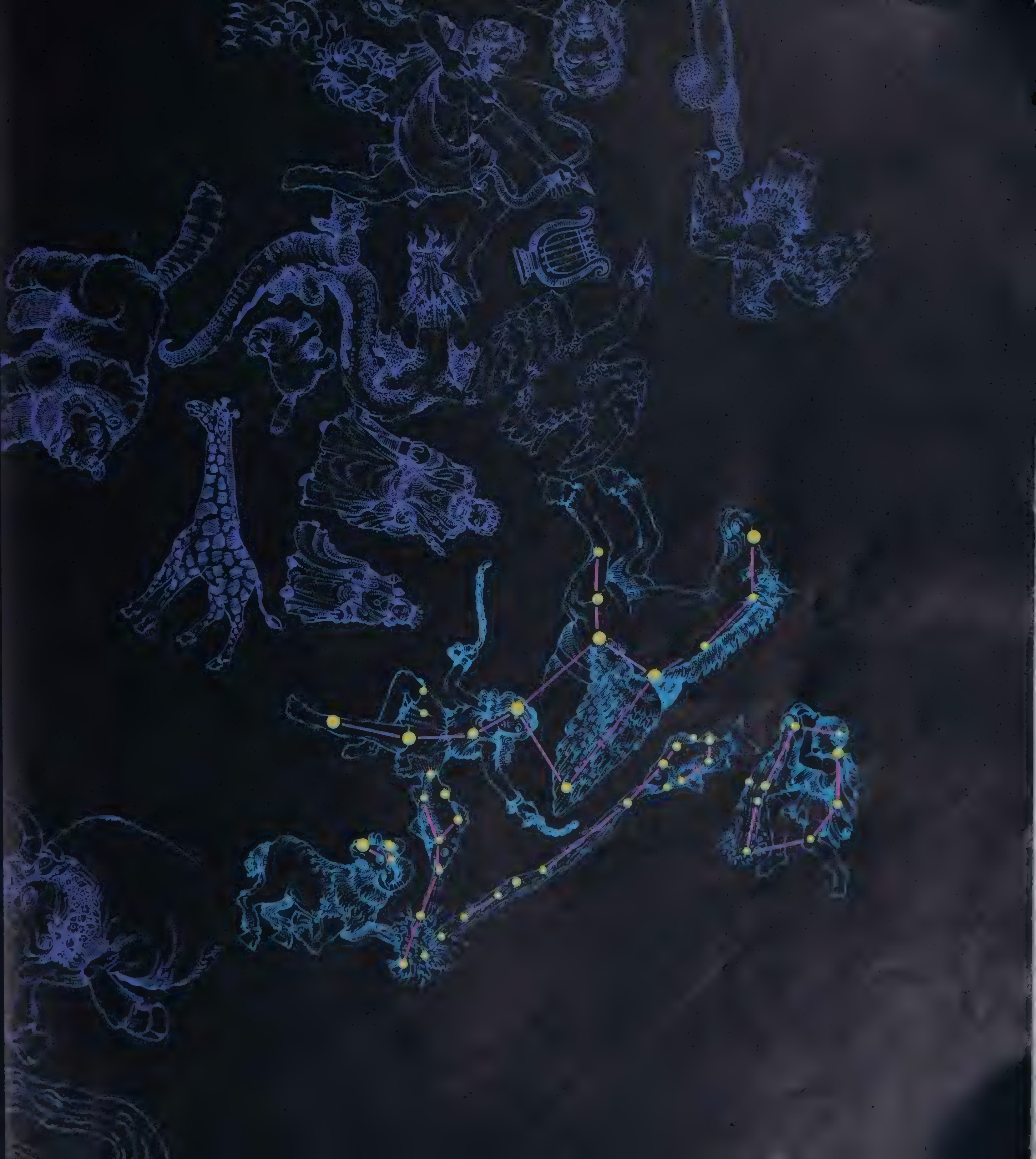
What are the main constellations for each season of the year?

Each season of the year has its own particular pattern of stars in the night sky. Once you learn to recognize the main constellations of each season, they can be used as a guide along with your star chart to find and name other stars. When using your star-finder chart outside, remember to orient it over your head and face the direction in which the star or constellation in which you are interested is to be found. Make sure that the north on your chart is lined up with true north. Use a flashlight with the bulb painted red or the lens covered with red cellophane to read the star-finder chart. Since white light deadens the ability of your eyes to see the stars, try to avoid it.

Stars appear to rise in the east and set in the west. If you observe one star for a number of days at the same time of day, you will find the star to be slightly west of its former position each day. For example, stars observed in the east at 21:00 appear higher and higher in the southern sky each succeeding night. This idea can be readily illustrated with your star chart. Pick out a star. Now turn the disc of the chart ahead a number of days. Is the star slightly west of its former position? When answering the questions in this activity look at the portion of the sky south of the east-west thread and directly overhead.

THE WINTER SKY

Of all the months of the year February is the best for stargazing. It has an exciting parade of stars each with an interesting story to discover. In the



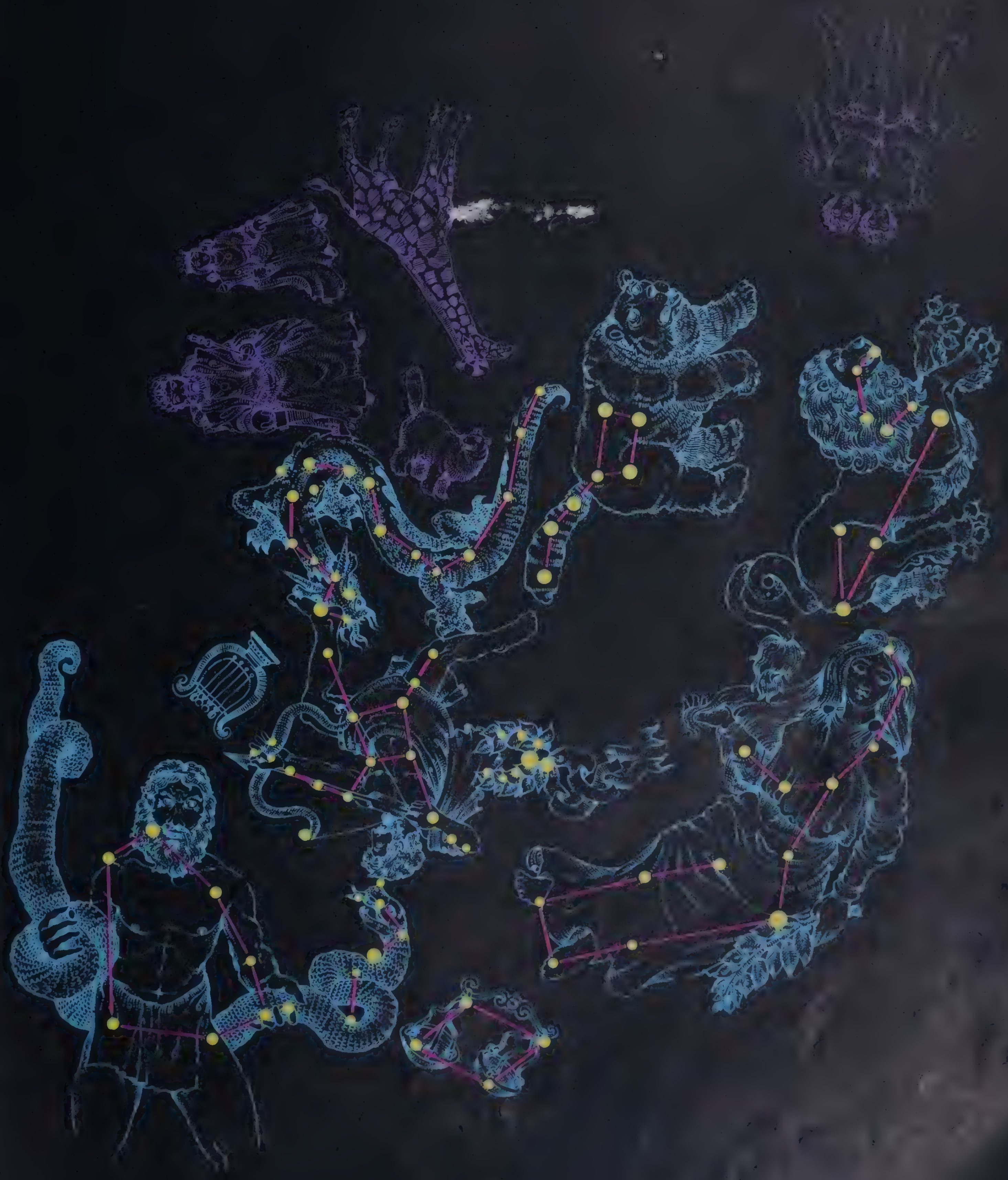
winter the early evening darkness allows you to stargaze at a convenient hour of the night.

Set your star-finder chart for 20:00, February 15. Locate the constellation Orion. It will be on the north-south thread in the southern half of the sky at an elevation of about 45°. Orion, the Hunter, is one of the best known constellations in the sky. Three stars make up Orion's belt, while Betelgeuse, a giant red star, indicates his right shoulder. Rigel, a brilliant blue star, is positioned at Orion's left knee. He appears to be holding his right arm over his head. If you imagine a line drawn along Orion's belt and continued toward the southeast, you will arrive at another star, called Sirius, the Dog Star. Sirius is the second brightest star we see in the sky. What is the brightest star in the sky? Sirius is the nose of Orion's hunting dog, Canis Major. Orion has two hunting dogs, can you locate and name the second one? This smaller dog contains the star, Procyon. By continuing the imaginary line along Orion's belt in the opposite direction (to the right) you will just pass under the horns of Taurus, the Bull, and Pleiades, the Seven Sisters. The horns of Taurus form a V-shape in the sky and contain the star, Aldebaran. Pleiades is actually located on the shoulder of the Bull. Usually only six stars are readily visible but when viewed with a telescope many more can be seen. Orion is supposedly out hunting Taurus with his two dogs, but some people think he might be looking for the Seven Sisters. The horns of Taurus point toward two stars located on the east-west thread above Orion's second dog, Canis Minor. These stars are the Gemini twins, Pollux and Castor. The Romans prayed to Pollux and Castor, using their names in oaths and curses. To this day one hears the expression *By Jiminy!* from the ancient oath *By Gemini!*

At the zenith is the constellation Auriga. In it is the bright star Capella. Capella, Pollux, Castor, Procyon, Sirius, Rigel, and Aldebaran form a nearly perfect circle around Betelgeuse, the beautiful reddish giant. All these stars together make up the A-circle of the winter sky. At no other time of the year do so many bright stars appear in the heavens at the same time. Betelgeuse, one of the largest stars man has discovered has a diameter of 644 000 000 km.

THE SPRING SKY

The spring sky contains the best known and most easily recognizable of all the constellations, the Big Dipper, also known as the Big Bear. It can always be seen in the sky since it never rises or sets. Although the spring sky is not as spectacular as the winter sky, it does contain three bright stars. Set your star-finder chart for 21:00, April 15 and locate the Big Dipper. How many stars are in the Big Dipper? The two end stars in the bowl of the Dipper, Merak and Dubhe, should be located on the north-south thread. These two stars are called the pointer stars because they point to Polaris, the North Star.



Polaris is not an extremely bright star but man can use it to find direction because it is located almost directly over the earth's north pole and because all the other stars in the sky seem to rotate around it during the night. Polaris is the end star in the handle of the Little Dipper. The Little Dipper is also called the Little Bear.

Look at the Big Dipper again and notice the gentle arc or curve its handle makes toward the east and south. Follow that arc to a bright star Arcturus, in the constellation Boötes, which is directly behind the Big Dipper or Ursa Major. Boötes is known both as the Herdsman and as the Driver of the Bears. He is said to continually drive the Bears around the North Star. Lower, and to the right of Boötes, in the eastern sky is a small U-shaped group of stars known as the Northern Crown or Corona Borealis. Alphecca is the brightest star in the Corona Borealis. How many stars are in the crown?

A continuation of the arc southward brings you to another bright star, Spica, in the constellation Virgo, the Maiden. At the foot of Virgo, and to the east, on the horizon is the constellation Libra, the Scales, the symbol for justice. What shape is Libra?

Beyond Spica, and to the west of it near the southeastern horizon is Corvus, the Crow. Corvus is also known as the Mainsail.

The last and most prominent constellation of the spring sky is the Lion, Leo. Leo is almost overhead at the zenith. The head of the lion resembles a backward question mark with the star Regulus, as the dot. The tail end of the lion resembles a small triangle. Legend has it that the first of the Twelve Labors of Hercules was to kill the lion which could not be injured with a sword, a spear, or an arrow. Read to discover how Hercules killed the beast.

THE SUMMER SKY

Since it stays light much longer in the summer, it will be necessary to view the stars at a later hour than in the winter and spring. The summer sky like the spring sky has three bright stars in it. The three stars form a triangle which is known as the *summer triangle*.

Set your star-finder chart for 23:00, July 15. What is the name of the constellation found at the zenith? This group of stars contains the star, Vega. Vega is a very bright and easy star to locate. The constellation Lyra is also referred to as the Harp.

East of Lyra on the east-west thread is the constellation Cygnus. Cygnus means the Swan but it is often called the Northern Cross. How are Cygnus and Lyra related in ancient mythology? The brightest star in Cygnus is called Deneb. Deneb is located in the tail of the Swan.

Below Cygnus and to the southeast is found another constellation Aquila, the Eagle. Aquila's brightest star is called Altair, the Shoulder of the Eagle. Altair, Vega, and Deneb make up the

summer triangle.

West of Lyra on the east-west thread is found a constellation which immortalizes the most popular hero of ancient mythology, Hercules. He has his foot on the head of Draco, the Dragon, and is about to club him, while in his other hand Hercules holds the golden apples from the Garden of Hesperides which Draco guarded.

To the south of Lyra on the north-south thread near the horizon is the Archer, Sagittarius. Sagittarius was a centaur, who lived on a mountain in Thessaly. What is a centaur? Sagittarius is sometimes called the Teapot.

Directly west of Sagittarius and southwest of Lyra, almost on the horizon, is Scorpius, the Scorpion. Antares is the brightest star in Scorpius. Three stars make up the head of the scorpion while its tail or stinger is shaped like a fishhook. Ancient myths state that Scorpius stung Orion to death, but since the gods honored both Orion and Scorpius they put them in the sky at different times of the year. Orion and Scorpius can never be seen above the horizon at the same time. Orion appears in the winter sky and Scorpius in the summer sky. Use your star chart to verify this statement.

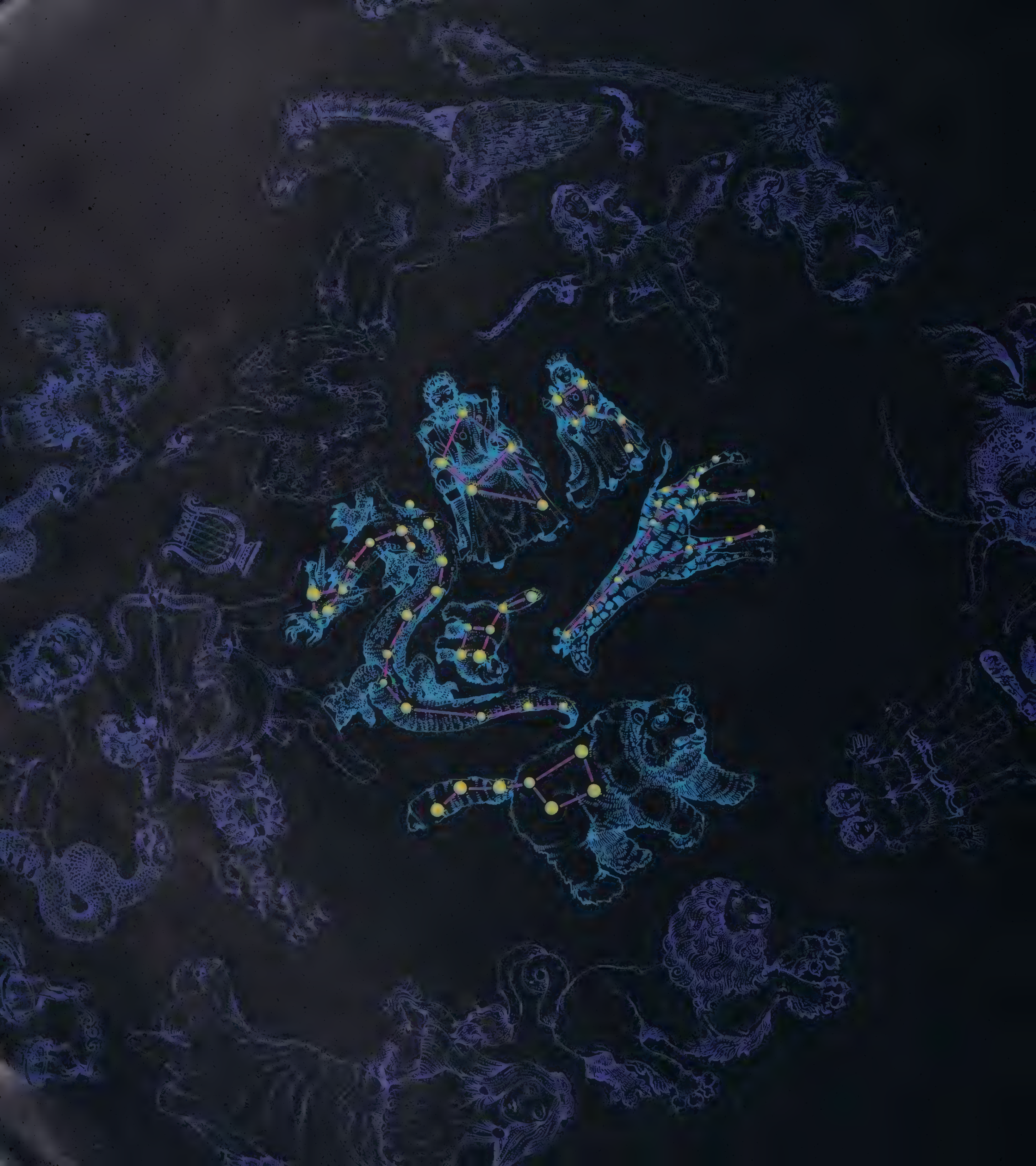
THE AUTUMN SKY

Of all the seasons of the year, each with its own parade of stars, the autumn sky is the least spectacular. It contains very few bright stars. The summer triangle has moved off to the west and Orion is just rising on the eastern horizon. However, the cool, dry nights and early sunsets allow for easy exploration of the heavens.

Set your star chart for 22:00, October 15. How many bright stars can you find? Overhead is the Great Square of Pegasus, which represents the body of the winged horse. The horse is really made up of two constellations, Pegasus and Andromeda. Andromeda makes up the hind leg of the horse. This view is open to other interpretations. The square is the body of the horse, while the line of stars leading toward Cygnus represents the front leg of the horse as it gallops through the night sky.

South of Pegasus and between Aquarius and Cetus lies Pisces, the Fishes. To the west of Aquarius, the Water Carrier, is Capricornus, the Goat. East of the Water Carrier is Cetus, the Sea Monster. Legend has it that Cetus is swimming through the night sky toward Andromeda with intentions of devouring her. South of Aquarius, near the horizon is positioned Piscis Austrinus, the Southern Fish. This group of stars contains the only bright star of the fall parade. This star is Fomalhaut.

Locate Aries, the Ram. Aries is on the east-west thread between Andromeda and head of Cetus. Now look east of Aries toward the horizon. What constellation is found there? This is probably the longest winding constellation in the sky. It is called Eridanus, the River of the Sky. What constellation does Eridanus join to the northeast?



THE POLAR STARS

Last, but not least, are the stars found around Polaris, the North Star. These particular stars belong to every season for they never set. Observe the North Star on your star chart. Examine the constellations immediately around it. Now turn your star-finder chart counterclockwise and discover the constellations around Polaris which never go below the horizon.

If you can find six constellations which do not disappear you are a careful observer. Name the six which never set. The stars in these constellations are said to be *circumpolar* stars since they seem to revolve around the Pole Star, yet do not go below the horizon. The constellation names are: the Little Dipper; the Big Dipper; Draco, the Dragon; Cassiopeia, the Queen; Cepheus, the King; and Camelopardalis, the Giraffe. Cepheus resembles a house, while Cassiopeia, his queen, looks like the letter W. Run your finger over the constellation Draco. Where is Draco's head located?

Learning to use the star-finder chart is only a beginning. Now you must go out-of-doors armed with your chart and your skills and look at real stars. Do not be in a hurry to find everything at once. Locate one or two constellations and watch them for several nights. Then move on to another group of stars. The constellations on your star chart are extremely small as compared to the actual constellations in the sky. The spaces between the real stars are much larger than you imagined and they will cover huge areas of the sky.

Digging Deeper

What is a constellation?

What are the names of three of the winter constellations? summer

What stars make up the summer triangle?

Why are some constellations visible all year round?

If you were standing on the earth's North Pole, how many circumpolar stars would you see?

Of all the stars on the star-finder chart, approximately how many are below the horizon at any given time?

What instructions would help a friend find Leo in the middle of the summer?

Branching Out

What is the closest star to us other than the sun? In what part of the sky is it located?

What is the *Milky Way?*

What does the *swastika* 卐 symbolize in astronomy?

What is *mythology?*

What were the Twelve Labors of Hercules?

What is an *asterism?* How is it related to a constellation?

Michigan State University produces a monthly "Sky Calendar" which gives an excellent day by day description of the stars and what to look for in the sky. The calendar consists of a single

Larger starcharts should be hung on a north wall with the current month at the top.

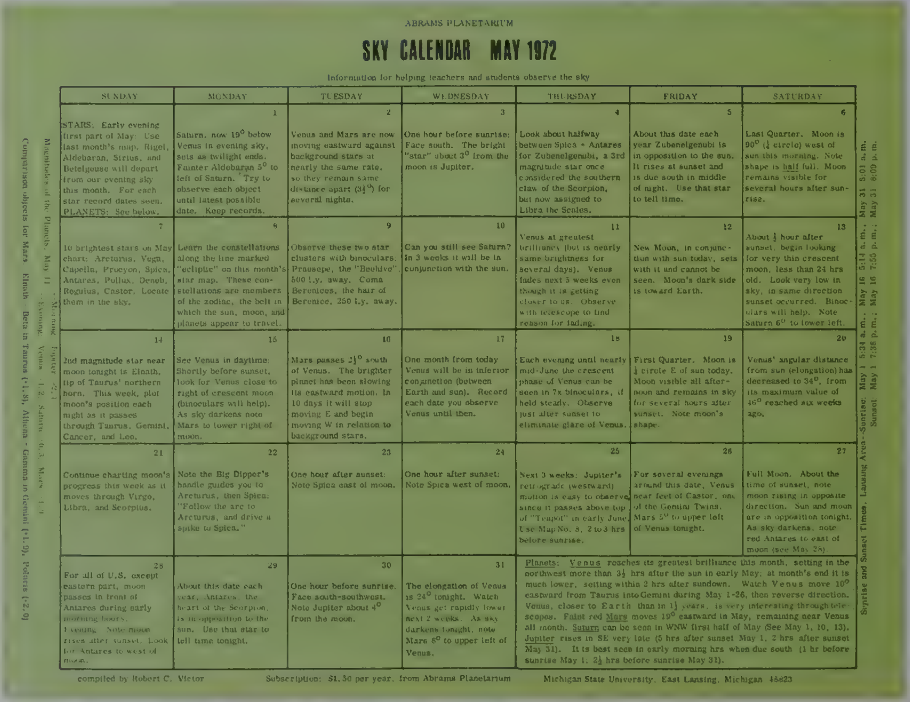
sheet of paper with each day of the month blocked off on one side. [Each block contains information for a particular day.] On the other side is either a current evening sky map or an article describing an unusual event in the sky for the month. This is one of the best aids to astronomical observations available. The calendar appears monthly in *Science and Children,* or separate issues are available by mail. A yearly subscription to the calendar can be obtained by sending $1.50, by cheque or money order, to:

Sky Calendar
Abrams Planetarium
Michigan State University
East Lansing
Michigan 48823.

Obtain a large star map of the northern hemisphere from a High School and hang it on a north wall. Around the outer edge of the star chart, you should find the months of the year labelled. To hang the star map correctly so that it can be properly read, turn the map until the current month is at the top. This will give you the constellations which are visible at 21:00 around the middle of this month. Keep in mind when reading the wall map that you must imagine it as being located above your head and that the center on any map is the point directly overhead.

point directly overhead.

Contact your nearest science museum, public library, planetarium, or observatory and ask about their program on astronomy for each season of the year. Telescopes and binoculars extend one's



ABRAMS PLANETARIUM

SKY CALENDAR MAY 1972

Information for helping teachers and students observe the sky

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
STARS: Early evening first part of May: Use last month's map. Rigel, Aldebaran, Sirius, and Betelgeuse will depart from our evening sky this month. For each star record dates seen. PLANETS: See below.	1 Saturn, now 19° below Venus in evening sky, sets as twilight ends. Fainter Aldebaran 5° to left of Saturn. Try to observe each object until latest possible date. Keep records.	2 Venus and Mars are now moving eastward against background stars at nearly the same rate, so they remain same distance apart (3½°) for several nights.	3 One hour before sunrise: Face south. The bright "star" about 3° from the moon is Jupiter.	4 Look about halfway between Spica + Antares for Zubenelgenubi, a 3rd magnitude star once considered the southern claw of the Scorpion, but now assigned to Libra the Scales.	5 About this date each year Zubenelgenubi is in opposition to the sun. It rises at sunset and is due south in middle of night. Use that star to tell time.	6 Last Quarter. Moon is 90° (¼ circle) west of sun this morning. Note shape is half full. Moon remains visible for several hours after sunrise.
7 10 brightest stars on May chart: Arcturus, Vega, Capella, Procyon, Spica, Antares, Pollux, Deneb, Regulus, Castor. Locate them in the sky.	8 Learn the constellations along the line marked "ecliptic" on this month's star map. These constellations are members of the zodiac, the belt in which the sun, moon, and planets appear to travel.	9 Observe these two star clusters with binoculars: Praesepe, the "Beehive", 500 l.y. away. Coma Berenices, the hair of Berenice, 250 l.y. away.	10 Can you still see Saturn? In 3 weeks it will be in conjunction with the sun.	11 Venus at greatest brilliancy (but is nearly same brightness for several days). Venus fades next 5 weeks even though it is getting closer to us. Observe with telescope to find reason for fading.	12 New Moon, in conjunction with sun today, sets with it and cannot be seen. Moon's dark side is toward Earth.	13 About ½ hour after sunset, begin looking for very thin crescent moon, less than 24 hrs old. Look very low in sky, in same direction sunset occurred. Binoculars will help. Note Saturn 6° to lower left.
14 2nd magnitude star near moon tonight is Elnath, tip of Taurus' northern horn. This week, plot moon's position each night as it passes through Taurus, Gemini, Cancer, and Leo.	15 See Venus in daytime: Shortly before sunset, look for Venus close to right of crescent moon (binoculars will help). As sky darkens note Mars to lower right of moon.	16 Mars passes 2½° south of Venus. The brighter planet has been slowing its eastward motion. In 10 days it will stop moving E and begin moving W in relation to background stars.	17 One month from today Venus will be in inferior conjunction (between Earth and sun). Record each date you observe Venus until then.	18 Each evening until nearly mid-June the crescent phase of Venus can be seen in 7x binoculars, if held steady. Observe just after sunset to eliminate glare of Venus.	19 First Quarter. Moon is ¼ circle E of sun today. Moon visible all afternoon and remains in sky for several hours after sunset. Note moon's shape.	20 Venus' angular distance from sun (elongation) has decreased to 34°, from its maximum value of 46° reached six weeks ago.
21 Continue charting moon's progress this week as it moves through Virgo, Libra, and Scorpius.	22 Note the Big Dipper's handle guides you to Arcturus, then Spica: "Follow the arc to Arcturus, and drive a spike to Spica."	23 One hour after sunset: Note Spica east of moon.	24 One hour after sunset: Note Spica west of moon.	25 Next 3 weeks: Jupiter's retrograde (westward) motion is easy to observe since it passes above top of "Teapot" in early June. Use Map No. 5, 2 to 3 hrs before sunrise.	26 For several evenings around this date, Venus near feet of Castor, one of the Gemini Twins. Mars 5° to upper left of Venus tonight.	27 Full Moon. About the time of sunset, note moon rising in opposite direction. Sun and moon are in opposition tonight. As sky darkens, note red Antares to east of moon (see May 28).
28 For all of U.S. except eastern part, moon passes in front of Antares during early morning hours. Evening: Note moon rises after sunset. Look for Antares to west of moon.	29 About this date each year, Antares, the heart of the Scorpion, is in opposition to the sun. Use that star to tell time tonight.	30 One hour before sunrise. Face south-southwest. Note Jupiter about 4° from the moon.	31 The elongation of Venus is 24° tonight. Watch Venus get rapidly lower next 2 weeks. As sky darkens tonight, note Mars 8° to upper left of Venus.	Planets: Venus reaches its greatest brilliance this month, setting in the northwest more than 3½ hrs after the sun in early May; at month's end it is much lower, setting within 2 hrs after sundown. Watch Venus move 10° eastward from Taurus into Gemini during May 1-26, then reverse direction. Venus, closer to Earth than in 1½ years, is very interesting through telescopes. Faint red Mars moves 19° eastward in May, remaining near Venus all month. Saturn can be seen in WNW first half of May (See May 1, 10, 13). Jupiter rises in SE very late (5 hrs after sunset May 1, 2 hrs after sunset May 31). It is best seen in early morning hrs when due south (1 hr before sunrise May 1; 2½ hrs before sunrise May 31).		

Magnitudes of the Planets, May 11 --Morning: Jupiter -2.1
--Evening: Venus -4.2, Saturn +0.3, Mars +1.9

Comparison objects for Mars: Elnath - Beta in Taurus (+1.8), Alhena - Gamma in Gemini (+1.9), Polaris (+2.0)

Sunrise and Sunset Times, Lansing Area--Sunrise: May 1 5:34 a.m., May 16 5:14 a.m., May 31 5:01 a.m.
Sunset: May 1 7:38 p.m.; May 16 7:55 p.m.; May 31 8:09 p.m.

compiled by Robert C. Victor Subscription: $1.50 per year, from Abrams Planetarium Michigan State University, East Lansing, Michigan 48823 powers of observation. If it is at all possible, obtain either of these pieces of equipment. They will unlock even more of the secrets of the heavens.

Construct your own planetarium. This homemade one consists of a cardboard dome constructed from 6 pentagons and 10 triangles with all sides measuring 60 cm. *The whole structure is bolted together and suspended from the ceiling by a pulley. The dome represents the starry sphere. A simple star projector can be made or purchased from the Harmonic Reed Corporation, Rosemont, Penn. U.S.A. Once your planetarium is set up it will be possible to identify stars, motion of stars, the zenith, horizon, and latitude.*

Activity 4:

How can the brightness of stars be determined?

Stars vary in brightness. The brightness of a star is called its magnitude, and is expressed as a numeral. There are stars of magnitude 0, stars of magnitude 1, stars of magnitude 2, and so on. The greater the magnitude, the dimmer or less bright the star is. The unaided eye can see stars of magnitude 6 but beyond this binoculars or telescopes are required. They can discover stars as dim as the twentieth magnitude. Each magnitude is 2.5 times brighter than the next magnitude; for example, a second magnitude star is 2.5 times brighter than a third magnitude star. Learning the first and second magnitude stars of the sky will aid you greatly in being able to locate almost all of the best known constellations.

Astronomers have devised a way of naming each of the stars in a constellation in order to establish an accurate point of reference. This is useful when stars and star clusters are to be pinpointed in a constellation. Each star in a constellation is assigned a letter from the Greek alphabet: alpha, beta, gamma, delta, epsilon, zeta, eta, and so on. There are twenty-four letters in all. The brightest star in a constellation is called an alpha star. Next are the beta stars, the gamma, and so on. Read to discover the other letters of the Greek alphabet and their symbols.

You can determine the brightness or magnitude of real stars by constructing the following simple device out of cardboard and cellophane.

Obtain a piece of heavy, stiff cardboard 25 cm x 5 cm. Divide the strip into five equal parts and in the center of each section draw a circle. Carefully cut out each circle from the cardboard. Now obtain some clear, colorless cellophane and cut it into the following lengths: 25 cm x 5 cm, 20 cm x 5 cm, 15 cm x 5 cm, 10 cm x 5 cm and 5 cm x 5 cm.

Tape or glue the longest piece of cellophane squarely onto the strip of cardboard. Do the same with the next longest piece of cellophane. Glue it on squarely so that it covers only the last four holes. Tape the next smallest piece over the last three holes and the other pieces in a like manner until all the pieces are fixed to the cardboard strip. You should end with five layers of cellophane over the last hole. Label this hole 1; the hole with four cellophane sheets is labelled 2; and so on. These numerals are used to find the approximate brightness of a star. Make sure that each window is absolutely free and clear of tape or glue.

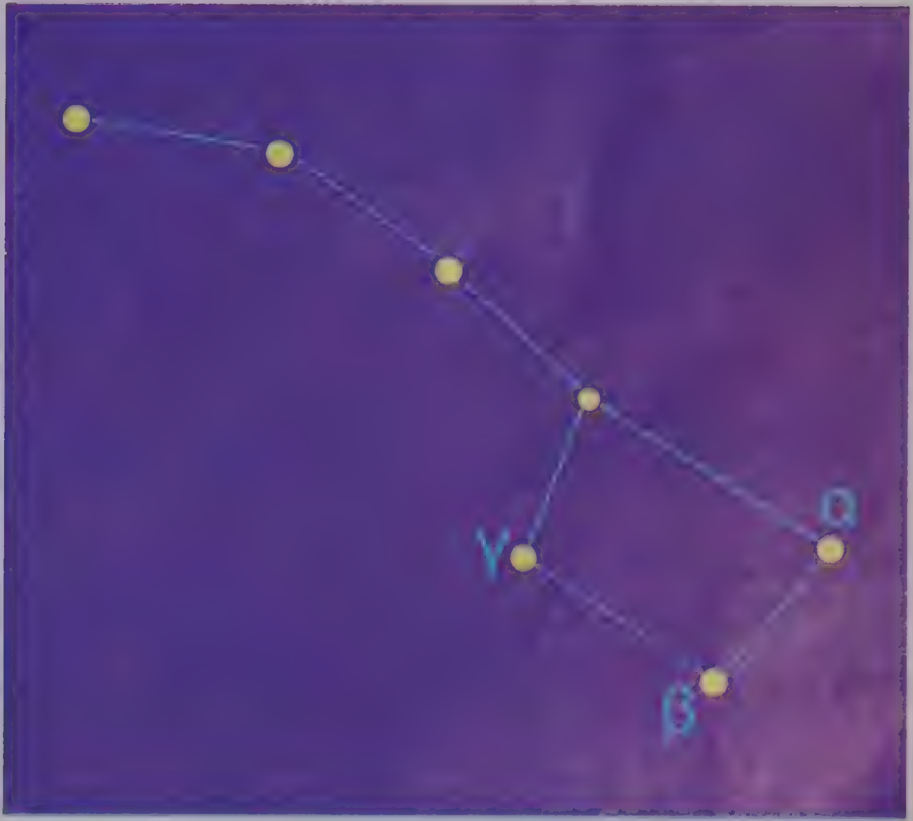
To use your star brightness device locate the star whose magnitude is to be checked. Observe it first through the window which has five layers of cellophane over it. If the star can be seen it is a first magnitude star. If the star cannot be seen through this window use the one with four layers of cellophane. If the star now appears it is a second magnitude star. If only three layers of cellophane can be used

Follow the instructions carefully when making a star brightness indicator.

the star is of the third magnitude. Two layers indicate a fourth magnitude star. One layer shows a fifth magnitude star.

As a preliminary check on your brightness device observe several stars of known brightness. For example, the first three stars in the handle of the Big Dipper are second magnitude stars; the next two in the bowl are third magnitude stars. Consult with star maps and charts before final decisions are made regarding a star's brightness since the method suggested is a crude one.

What does the symbol by each star indicate?



Digging Deeper

Use your star-finder chart to determine the season with the most first magnitude stars.

What magnitude of star is most common in the six circumpolar constellations?

Branching Out

Do stars ever change in brightness? What is a variable star?

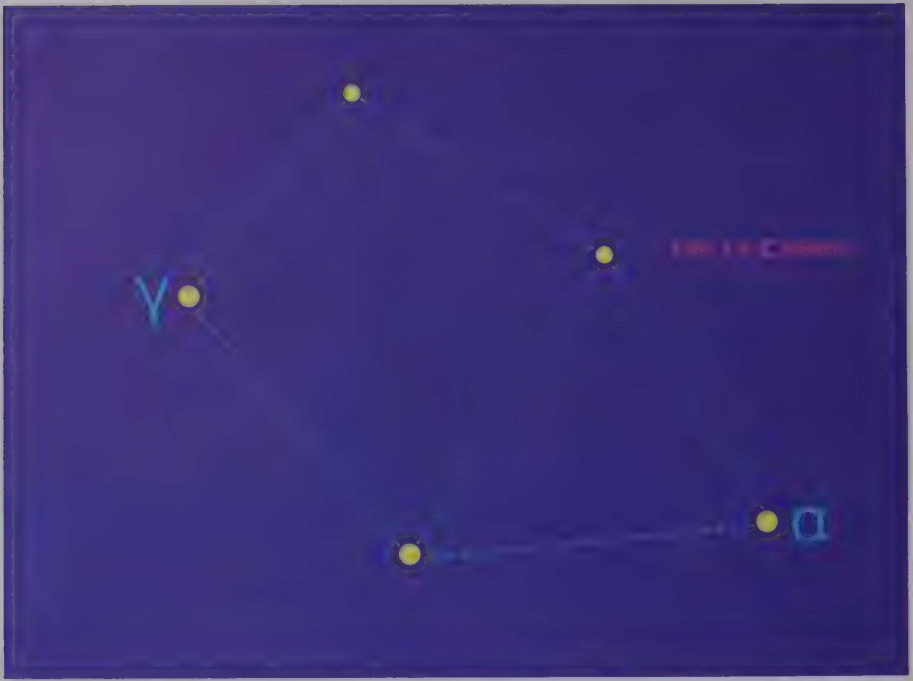
Who was the first man to classify stars according to their brightness?

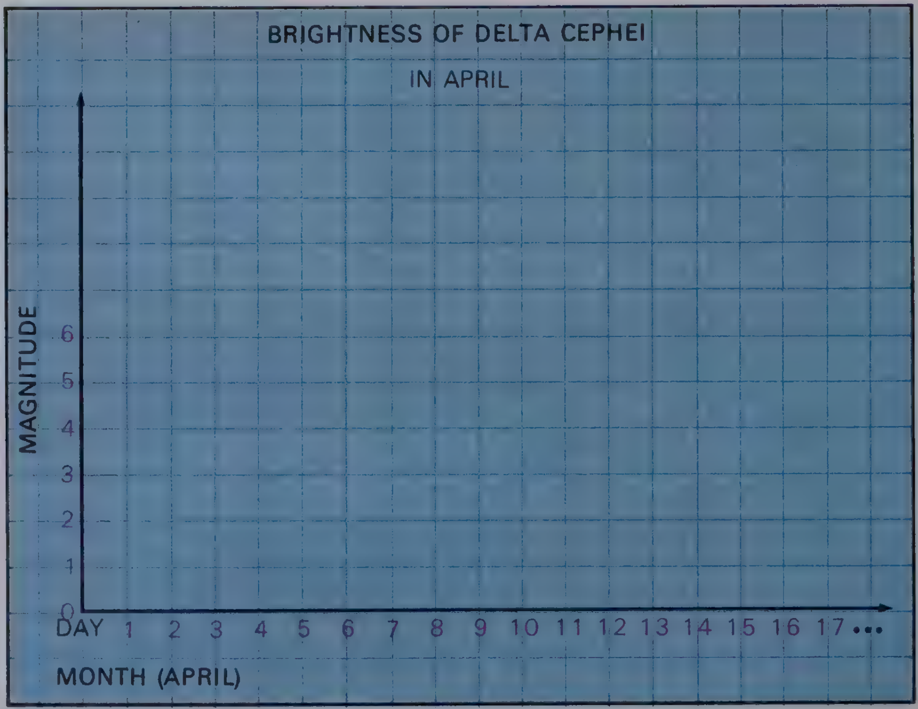
What contribution concerning the magnitude of stars did Sir John Herschel make?

One of the six polar constellations is Cepheus, near Cassiopeia. Cepheus contains five stars in the shape of a crude house. One of its stars, Delta Cephei, continuously changes brightness in a regular cycle every four days.

Using the brightness tester, observe Delta Cephei, for two or three weeks and plot its brightness on a graph similar to the one shown. It may be difficult to obtain good results using your brightness tester.

Read why Delta Cephei changes in magnitude. If you would like the names of other interesting variable stars which you can observe, write to your nearest planetarium, science museum, or observatory.





Delta Cephei is known as a variable star.

Be sure to center the portion of the sky you wish to photograph in the viewfinder before taking the picture.

Activity 5:

How can you photograph the motion that the stars appear to make?

Previous activities have drawn to your attention that some stars rise in the east, and that some stars are circumpolar. Photographic records of the apparent motions in the sky can be easily made. Almost any inexpensive camera will serve the purpose as long as it has a time-exposure setting or some means of keeping the shutter open.

The film in the camera has an advantage over your eyes in that it can store up light energy, whereas your eyes cannot. Try this! Look at something and then close your eyes. Can you still see it? Astronomers use the ability of film to store light energy to their advantage. Astronomers attach cameras to their telescopes because telescopes gather a lot of light. The film stores the light making the image on the film brighter. Therefore, astronomers can take pictures of the sky and locate objects which are invisible to the naked eye. Larger telescopes are not meant to give larger images but to gather more light.

To carry out this activity you will need a camera, a roll of black and white film, a tripod or other camera support, and a dark, clear, moonless night. Load your camera with the film and take your equipment outside to a dark, open place. It is extremely important to find a very dark location for this activity. Adjust the focus on the camera to infinity and the lens to its widest opening or aperture. Mount the camera firmly on its tripod or support so that it is pointing directly at the North Star. Center the star in the middle of the view finder on the camera.

Now open the shutter and leave it that way for about one hour. When the time has elapsed close the shutter and advance the film to the next frame. Point your camera in a new direction, perhaps directly at the zenith, and repeat the procedure used for photographing Polaris. Keep a record of each picture and the part of the sky it represents. If you are taking these pictures in January or February, point your camera at the three stars in Orion's belt. This will produce a very interesting effect in the picture. Once you have completed your photography have the roll of film developed as soon as possible. Make sure that the company processing the film knows that you were photographing stars.

Digging Deeper

How would the picture appear with an exposure time of a half-hour instead of one hour?

If you left your camera fixed on Polaris for six hours, what would happen to the length of the star trails? Why?

Why do the stars appear to move? Examine the *first* photograph you took of the northern sky. What is the bright spot in the picture? Where is Polaris located in relation to the other stars? Which star traced the smallest arc? Which is the brightest arc? Why? Is Polaris at the center of the picture?

Is Polaris directly over the earth's north pole?

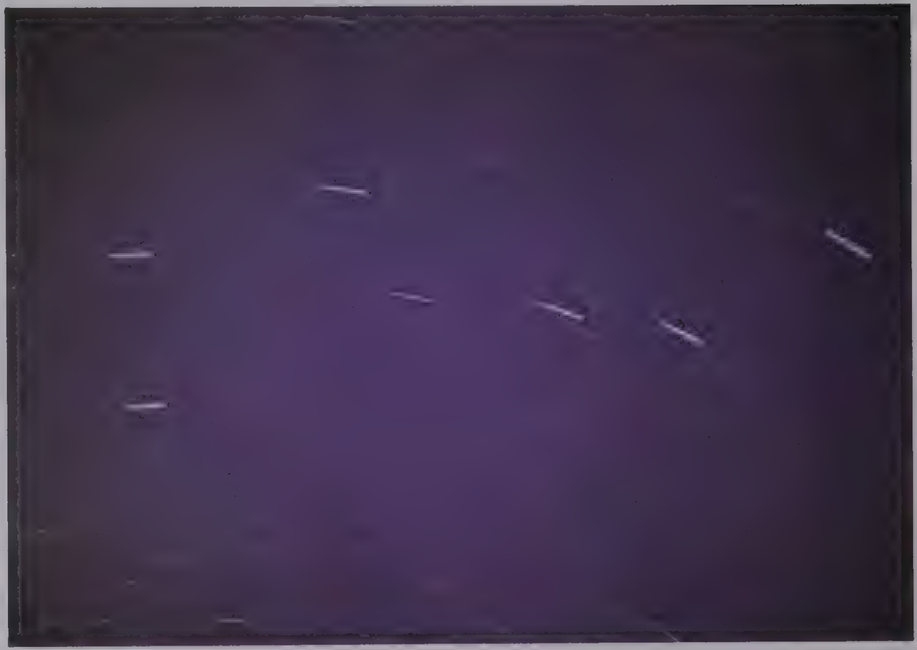
Explain why the stars usually make curved lines or arcs. Do the stars ever make straight lines in the sky? Where would they be located?

What does *apparent motion* mean?

Branching Out

Photograph the planet Jupiter using the star trail technique. Do not leave the shutter open for more than 30 min. Take weekly pictures for several months and then compare the location of Jupiter against the background of stars. Has it moved and, if so, which way? Refer to Chapter 5, page 81 to determine when and where Jupiter will be visible.

Take pictures of the same parts of the sky as you did initially, but at different seasons of the year. Check to see if the star trails are the same or different for each season.



At what part of the sky do you have to point your camera to get Star trails like these?

During the winter months when the trees are leafless, take a picture of the polar stars with your camera pointing up through the branches of a tree. The stationary branches will create an interesting effect on your photograph.

What is a *sidereal day?*

Activity 6:

What is astrology?

Astronomy is perhaps the oldest science. The Babylonians were probably the first to pursue astronomy and record their findings. Eudoxus, a Greek mathematician and astronomer, living around 400 B.C., constructed a globe of the starry sphere which indicated the position of the brightest stars. Hipparchus, who lived around 130 B.C., catalogued 1 080 stars. Ptolemy, an Egyptian astronomer-mathematician, classified stars according to their brightness. Ulugh Beg, an Arabian astronomer who lived around 150 A.D., catalogued 1 018 stars. Astronomy has been so interwoven with the lives of men that it was, for centuries, their religion. Today the universe has become our last frontier.

From the beginning, man has tried to predict events by the position of the stars and planets. These attempts to foretell future events by the stars are called *astrology*. Even today people buy books on astrology, read their horoscopes in daily newspapers, and listen to their astrological forecasts on the radio. Why? Because it is fun and people like to hear about themselves and about things that concern them.

In the sky there is a narrow band called the zodiac. This band is divided into twelve equal parts. Each part contains a constellation (one of the signs of the zodiac) through which the sun, the moon, and the planets appear to move during a year. Aries, the Ram, is the first sign of the zodiac while Pisces, the Fishes, is the last. Use your star-finder chart and a local newspaper to identify the other ten signs. See if you can discover what sign you were born under. Read the horoscopes of your friends and family. Find the period of time covered by each constellation of the zodiac using the star-finder chart. Are these dates the same dates as those given for the signs of the zodiac in the newspaper?

The 12 signs of the Zodiac.

Digging Deeper

Where is the watery part of the zodiac located? Name the constellations found in the watery part of the zodiac.

All of the constellations in the zodiac represent living creatures except one. Which one?

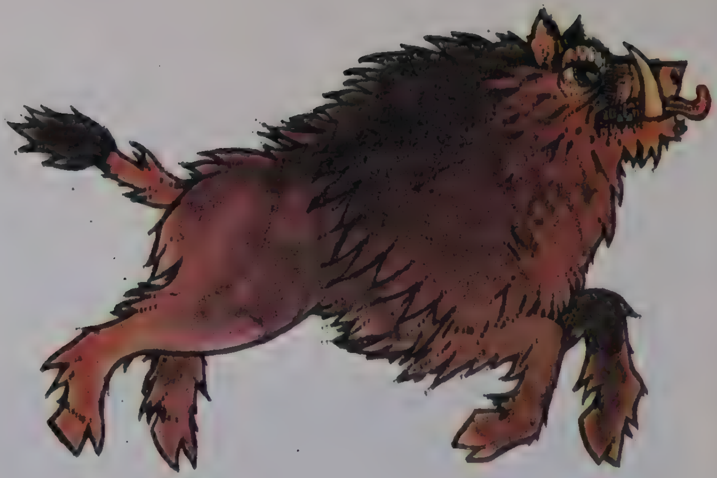
Can people really predict their lives and future events by the stars, the moon, and the planets?

Group the symbols of the zodiac by seasons.

Branching Out

Zodiac is a Greek word. What does it actually mean? What does the word zodiac mean to a scientist?

Are you a rat? Once you have looked up your horoscope in our zodiac, you might be interested in discovering what symbol you are in the Chinese zodiac. Their zodiac has twelve divisions too but, unlike ours, each lasts an entire year instead of a month. Each year is associated with an animal. 1972 is the year of the rat. 1973 is the year of the ox. 1974 is the year of the tiger. Examine the chart to discover what the Chinese zodiac has to say about you. First locate the year in which you were born, this will indicate what symbol you are, then read to find out what qualities people under that symbol are supposed to possess.



BOARS

Boars are often flirtatious. They do not 1947
always put all their cards on the table. 1959
There is a calm side to a boar's nature. 1971
Their heads are not in the clouds; they 1983
are very much on this earth. Boars are 1995
fond of food. They tend to spend more
than they earn.

DOG

Dog people are watchful and alert. They 1946
protect themselves and others against 1958
any possible decline of power and for- 1970
tune. Often dogs appear to nag, but 1982
this is usually for good reasons. Dog 1994
people are unselfish and sociable. They
give their best to others.

RAT

1936
1948
1960
1972
1984

People born in this sign are intuitive and can foresee good and bad luck for themselves and other people. Rats are usually lucky and bring luck to other people.

Because their minds and imaginations are so active, rats require a lot of rest. They should go to bed early and have rat-naps from time to time.

TIGER

1938
1950
1962
1974
1986

The tiger is associated with light, warmth, and activity, and is a symbol of power and military prowess. Tiger people are intense and positive, sometimes ferocious. If they are born after dusk, they are aggressive. Tiger people wake up raring to go. They get straight to the point. They may want to tear you to pieces, but at least you know where you stand with them. Deep down they have a real warmth. They are generous without being extravagant. Their lucky number is 7.

DRAGON

1940
1952
1964
1976
1988

The dragon is a symbol of rising power, adjusting well to change. Dragons are classified as big or small. Big dragons have riches, luck, power, and popularity. Small dragons have a smaller measure of these blessings. No dragon, big or small, likes to be pushed around.

ROOSTER

1945 Roosters are active, strong and hardy; 1957 they are not sentimental or sympathetic. 1969 But do not avoid them. The rooster wards off evil and is one of the 1981 most powerful signs. People born under 1993 this sign are punctual, reliable, and brave. Those born in the daytime are proud, reassuring, and confident.

OX

The ox is a sign associated with the earth, the moon, kindness, and love. Most ox people prefer privacy to the limelight, but they command respect. They are intuitive and bring luck to themselves and others. Leisure seems to agree with them.

1937

1949

1961

1973

1985

SNAKE

1941 The snake is a symbol of power and 1953 masculinity. People born in the snake year are respected but also feared. 1965 A boy born in this year is fortunate. 1977 Snake women are active and positive. 1989 They may not be born beauties, but they learn to make the most of themselves. Snakes tend to change constantly to meet changing conditions.

SHEEP

1943
1955
1967
1979
1991

Sheep have always a basic love and respect for their parents. Their parents' modes of life and conventions are good enough for them; sheep lack strong individual tendencies. They choose their words wisely, keep their feet on the ground, and look before they leap. They are shy, pessimistic, and puzzled. Sheep are usually lucky for other people. Sheep people are good-natured.

MONKEY

Monkeys can be disorderly, selfish, irritable, quarrelsome, fickle, mischievous, and unkind. They are cute, cunning, and sometimes crafty. Most monkeys are quite intelligent, though sometimes they hide it.

1944
1956
1968
1980
1992

HORSE

1942
1954
1966
1978
1990

The horse is a powerful sign. Horses are firm and reliable. They have stamina, strength, and speed, because they lead busy, active lives. Those born during the daylight hours hustle here and bustle there, but horses born during the night lead a quiet life. Horse people are skilful in paying compliments and are popular.

RABBIT

1939 Rabbits are very sensitive and can easily
1951 put themselves into the shoes of someone else. Because of this rabbits have
1963 a rich life and bring luck to other
1975 people.
1987 A rabbit's warmth is not readily apparent. Sometimes they shrink from physical contact. Rabbits detest brutality so they do not like to hunt. They are neither too good, nor too bad, and neither too rich, not too poor.

Activity 7:

How can a model of our galaxy be made?

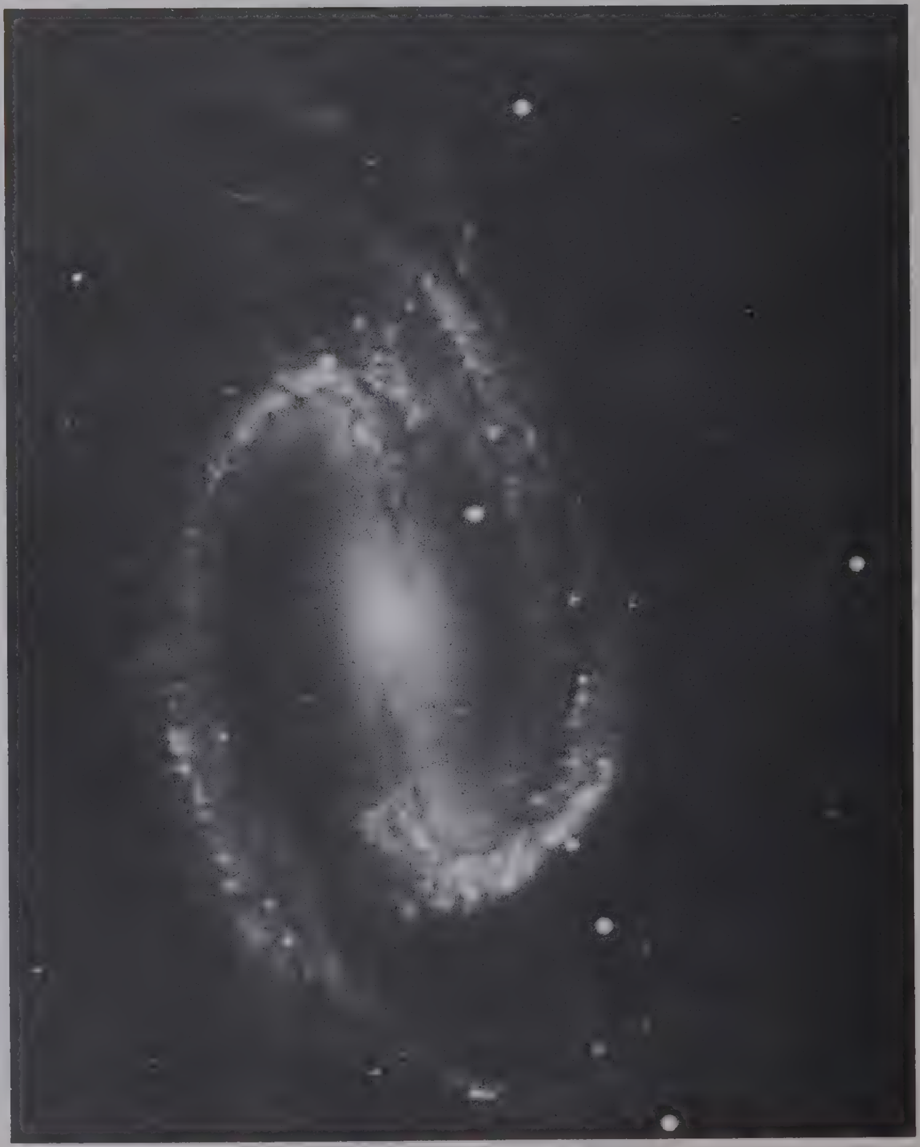
Astronomers have been charting the universe for thousands of years. They have discovered that we are part of a large cluster of stars somewhat like a huge, spiral-shaped island flying through space. Our island, or galaxy, called the Milky Way is made up of billions of stars. It covers a distance of trillions of kilometres, so great a distance that it is hard to imagine it. If you want to try, you might write down the figures for one trillion kilometres like this,

1 000 000 000 000 000 km

Now multiply this by 1 000 000 and see the long number you get. This number of kilometres gives you some idea of the distance across the Milky Way.

In order to talk about the great distances in space, astronomers use a unit called the *parsec.* One parsec (pc) equals almost 31 trillion kilometres or 31^{15} km. Using this unit can you find out how far away these stars are: Betelgeuse 150 pc; Vega 8 pc; Arcturus 11 pc?

If you look in the direction of the constellation Sagittarius you will see the Milky Way at its brightest since you



A spiral galaxy.

Where do galaxies appear to be thickest?

will be looking toward the center of the galaxy. Look at the constellation Auriga and you will be looking toward the edge of the galaxy.

Most of our home galaxy is just empty space. If grains of salt represented stars in a scale model of our galaxy there would be about 8 km between each grain of salt.

To construct a model of our galaxy obtain a piece of stiff cardboard, glue, and cotton batting.

Cut a circle with a 25 cm diameter from the cardboard.

Glue the cotton to the top and bottom of the cardboard disc so that there is a central wad of cotton with two or three arms coming out from it.

When the glue has dried, tease the cotton into shape so that when viewed from the side it resembles the galaxy in the sketch.

Digging Deeper

Approximately how many kilometres does 1 cm on your model represent?

Our galaxy is often referred to as an "island universe". Why?

Locate our solar system on the model using a straight pin as a marker.

Look at the pictures of other galaxies on page 3. Are all galaxies the same shape and size as our home galaxy?

Branching Out

The Milky Way appears as a fuzzy band of light across the sky. Using your star-finder chart, list the names of the constellations it appears to go through.

Why are galaxies called "cities of stars"?

Is the sun part of the Milky Way?

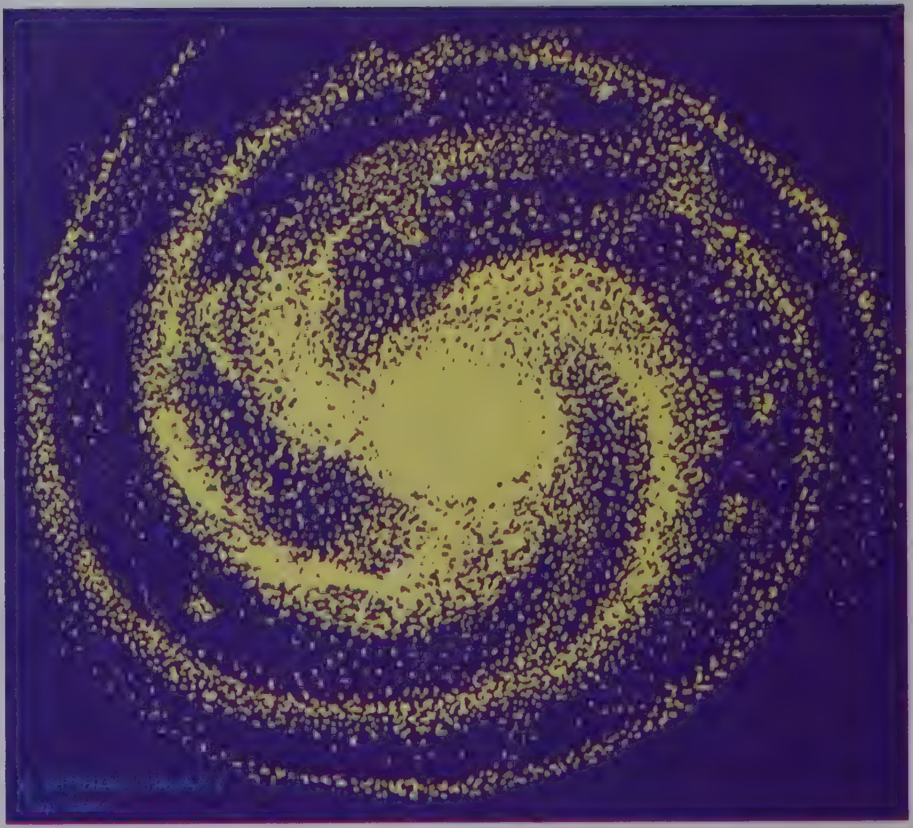
What holds these billions of stars together?

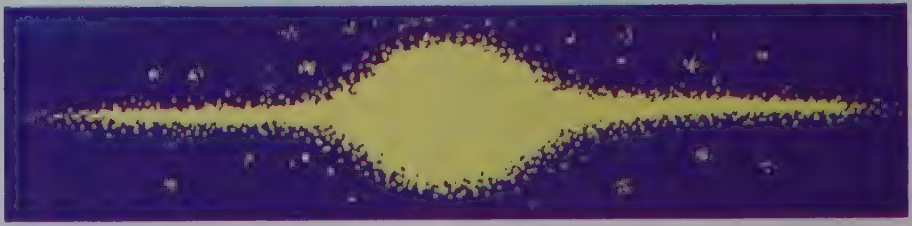
Astronomers have detected galaxies millions of petametres away. When they examine the light from these distant galaxies are they seeing the galaxy as it is or as it was? Explain.

Make models of the different types of galaxies.

Suppose you were going to write a letter to someone in another galaxy and you wanted to put your return address on the back of the envelope. What would your address be?

When viewing the constellations Orion and Andromeda one can see fuzzy bands of lights that are not stars but are really giant galaxies millions of petametres away. Attempt to locate these galaxies with binoculars.





Our Star — The Sun

3

3. Our Star — The Sun

B.C. by Johnny Hart

THE SUN RISES.
THE SUN SETS.
THE SUN RISES.
THE SUN SETS.
I CAN HARDLY WAIT TILL TOMORROW.
ANOTHER JAM-PACKED DAY OF CELESTIAL THRILLS.
B.C.
8-30
hart

By permission of John Hart and Field Enterprises Inc.

Did you know that your very existence depends upon a star? This star is the sun, one of the billions of stars in the Milky Way. To us our star is big, bright, and beautiful but compared to all the other stars it is only of average size. The sun gives us warmth, light, energy, and just about everything else we have. Without our star we would have a cold, dark, barren, lifeless planet.

Scientists have photographed our star more than any other. In fact more pictures have been taken of the sun than of any other single object. Using these photographs and telescopes, spectroscopes, radio telescopes, and other scientific equipment, scientists have gradually unlocked many of the sun's secrets to the advantage of mankind.

Captured solar energy is the major source of power today. Scientists have discovered the source of the sun's energy. Energy is released when under the extreme heat and pressure of the sun, atoms are joined together forming new substances. This process is called a *thermonuclear reaction*. Energy in the form of heat and light is radiated outward in all directions from the sun. The earth receives just the right amount of heat and light energy to sustain life. Of the total energy radiated out into space by the sun the earth receives very little. Yet this amount is equal to the energy released by 21 billion tonnes of coal burning every hour. Sunshine has given man coal, gas, oil, and even electricity.

The sun appears very large to us but as stars go it is a very ordinary, yellow star. The size of our star lies midway between the largest and the smallest of stars; the sun is cooler than the hottest blue stars and hotter than the coolest red stars. Our star can be classified among the *dwarf* stars.

In about 5 billion years from now, the hydrogen at the core of the sun will be used up and, as a result, the thermonuclear reactions will move closer to the sun's surface where greater quantities of hydrogen will be available. This will cause our sun to expand and engulf the planets Mercury and Venus, and perhaps earth in a red-hot gas! When most of the hydrogen has been converted to helium in the thermonuclear reactions, the sun will become cooler and smaller, shrinking to about the size of earth, with a density so great that each cubic centimetre of the sun will have a mass of several tonnes. Therefore, before the sun burns itself out we should hurry to complete the activities which follow!

DANGER: The sun can be very dangerous! The sun's rays can blind you if

What is a solar prominence?

you do not take the proper care when doing the activities. Never look directly at the sun with your naked eyes or especially with binoculars or telescopes.

Activity 1:

How can the position of the sun be measured using an astrolabe?

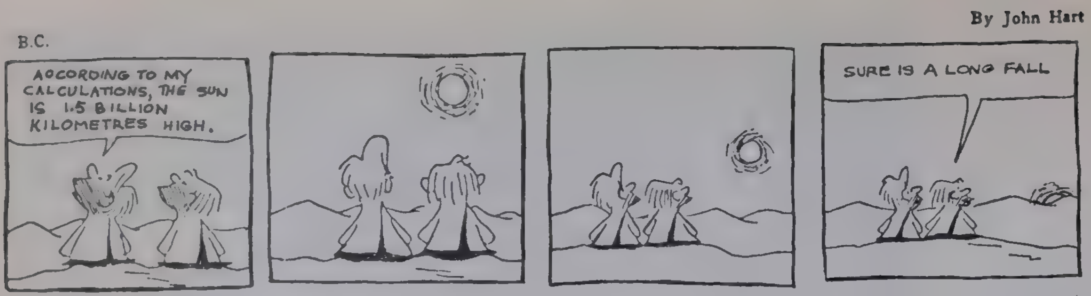
In Activity 3 of Chapter 1 you learned how to build and use an astrolabe. Now you are going to use the astrolabe to determine the position of the sun in the sky.

Due to the brightness of the sun it is dangerous to look directly toward it. So, in order to determine the sun's exact position we have to use an indirect method.

At approximately 11:00, on a clear, sunny day, take your astrolabe outside and place it on level ground. Make sure the base of the astrolabe is not tilted. Line up 0 on the full-circle protractor with true north. Without moving the base of the astrolabe, swing the top part of the instrument until the straw is pointing in the approximate direction of the sun. Hold a piece of paper at the end of the straw away from the sun. By trial and error move the straw until the light shines straight through the straw and lights up the paper.

This gives you the direction of the sun in the same way as you determined the position of stars in Chapter 1.

The altitude can be obtained from


B.C.
By John Hart
ACCORDING TO MY CALCULATIONS, THE SUN IS 1.5 BILLION KILOMETRES HIGH.
SURE IS A LONG FALL

By permission of Johnny Hart and Field Enterprises, Inc.

reading the numeral directly behind the thread on the half-circle protractor. The azimuth is read on the full-circle protractor from the position of the tin pointer.

The position of the sun as it moves across the sky is referred to as its *bearing*.

Use your astrolabe to keep track of the sun's elevation above the horizon at noon, each day, for one month.

The information collected could be recorded in a chart as shown. Be sure to use your astrolabe at exactly the same place each day.

Digging Deeper

Once the information has been gathered you might use it to answer these questions. What was the lowest angle the sun reached in the sky at noon? What was the highest angle above the horizon? What is the range in degrees between the highest and the lowest position of the sun above the horizon?

What is the sun's angle above the horizon at noon, 09:00, and 17:00 for a day this week?

Is the angle of the sun above the horizon different at noon on December 21 than at noon on June 21?

On the same day, find the approximate direction of the sun in degrees at noon, sunrise, and sunset.

Branching Out

The ancient Persians were the first to celebrate December 25 with coniferous trees or with what we call Christmas trees. What were they celebrating?

Construct a shadow-clock. Use a 2.5 cm x 20 cm x 20 cm block of wood and a 60 cm

ANGLE OF THE SUN ABOVE THE HORIZON

DATE	NOVEMBER 1	2	3	4	5	6	7
TIME							
ANGLE							

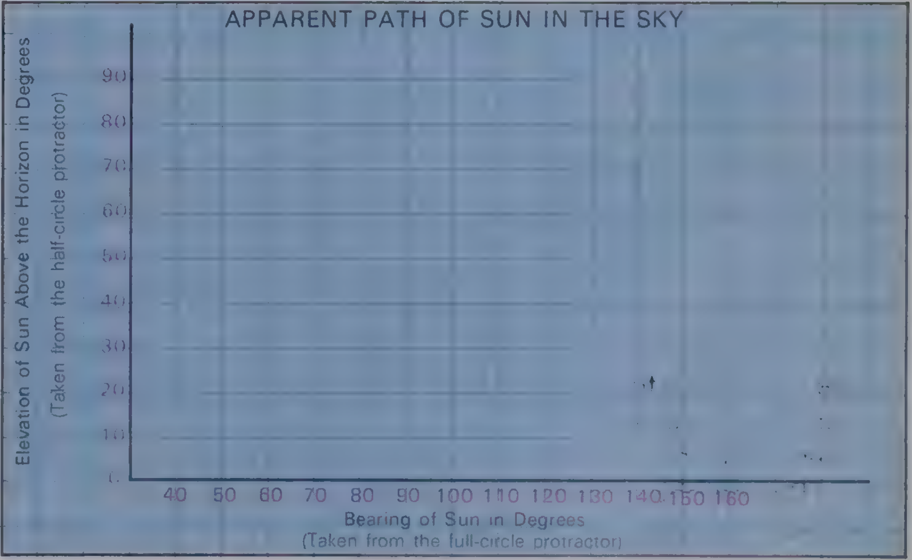
What is the angle of the sun, above the horizon, in this picture?

piece of 1 cm wooden dowel. Mount the dowel near the front and center of the block of wood by drilling a hole and gluing the two pieces together.

Place your shadow-clock out-of-doors on level ground and record the length of shadows during a day. In what direction does a morning shadow point? an afternoon shadow? For each day, is a 10:00 shadow exactly the same? Use a large piece of paper or cardboard under your shadow-clock and keep a record of the hourly shadows from 09:00 to 16:00 for the middle of each month for a six-month period. Compare the shadows of each month. When are the shadows longest? shortest?

Use your astrolabe to compile information about the sun's azimuth and altitude. Graph the data as shown. A line drawn through the plotted points will represent the sun's apparent path across the sky. The data collected and graphed could be for one day, one week, or one month, depending on the time available and your interest.

Obtain a cardboard mailing tube with a diameter of 7.5 to 10 cm and a length of 15 to 20 cm. Cut it in half along the length. Attach a stiff, square piece of cardboard to each end so that one edge of the cardboard is even with the top edge of the cylinder; this will allow the opposite edges of the cardboard square to act as a base for the tube. Tie a bead onto the middle of a piece of string and tape this to the cardboard as shown. This device, called a sun clock, should be placed


APPARENT PATH OF SUN IN THE SKY
Elevation of Sun Above the Horizon in Degrees
(Taken from the half-circle protractor)
90
80
70
60
50
40
30
20
10
0
40
50
60
70
80
90
100
110
120
130
140
150
160
Bearing of Sun in Degrees
(Taken from the full-circle protractor)

in a window facing south in January so that the string is in line with *north* and *south*. The end opposite the window should have another piece of heavy cardboard fixed to it so that the whole sun clock is tilted at an angle equal to your latitude (see Activity 3 in Chapter 1 for help in finding your latitude). The apparent motion of the sun will create a shadow which will move 15° each hour around the inside of the tube. This study will also show the sun's apparent shift with the seasons. Draw lines on the inside of the tube to record the seasonal shift of the sun. The hourly shift could be recorded for one of the days in each of the months from January to June.

Activity 2:

How can the sun's motion be plotted against the stars?

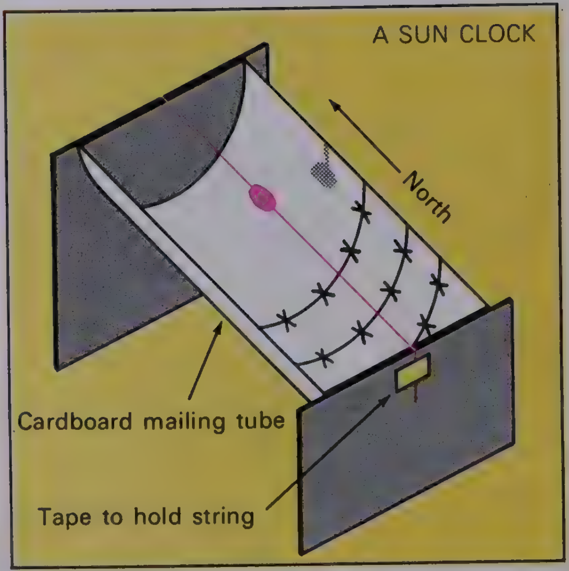
The moon and the planets move against a background of stars. The sun also has a background of stars but these stars are impossible to see because of the sun's brightness. Because of the movement of the earth around the sun, the sun has a changing background of stars. Your star chart can be used to locate the stars in the background of the sun on any day of the year.

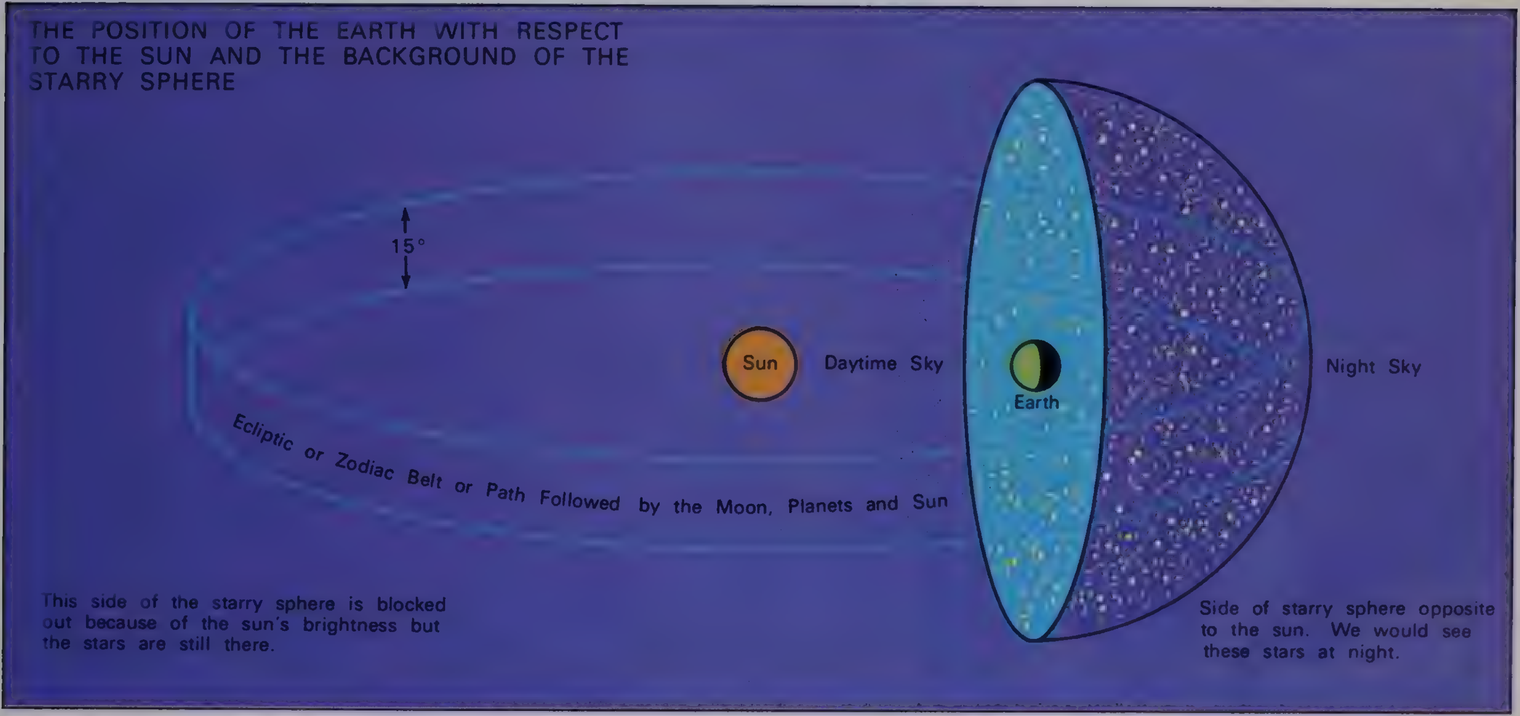
Observe the sun for several days to discover the direction in which the sun rises and the direction in which it sets. Record the time of rising and setting to the nearest half-hour. Use this data to set your star-finder chart. Determine from the chart the constellations in the western sky immediately after sunset. Do the same for the eastern sky immediately before sunrise. The constellations appearing just after sunset are *east* of the sun; the sunrise constellations are *west* of the sun. The background stars to the sun consist of those constellations falling between the sunrise and the sunset constellations.

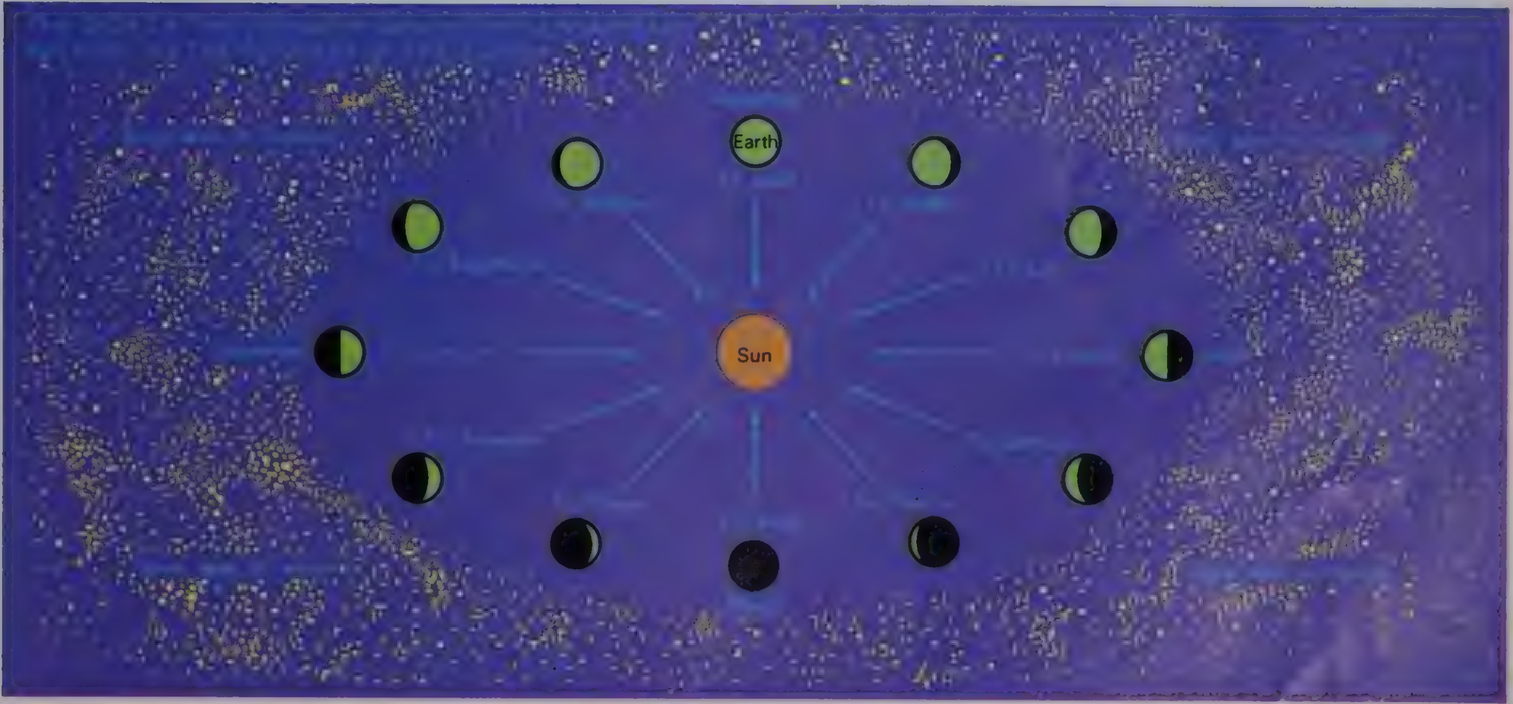
Digging Deeper

How accurate do you feel this method of plotting the sun is?

If you observed the constellation Taurus in the evening sky, in what constellation would the sun be, in the daytime sky?




THE POSITION OF THE EARTH WITH RESPECT TO THE SUN AND THE BACKGROUND OF THE STARRY SPHERE
15°
Sun
Daytime Sky
Earth
Night Sky
Ecliptic or Zodiac Belt or Path Followed by the Moon, Planets and Sun
This side of the starry sphere is blocked out because of the sun's brightness but the stars are still there.
Side of starry sphere opposite to the sun. We would see these stars at night.


Earth
Sun

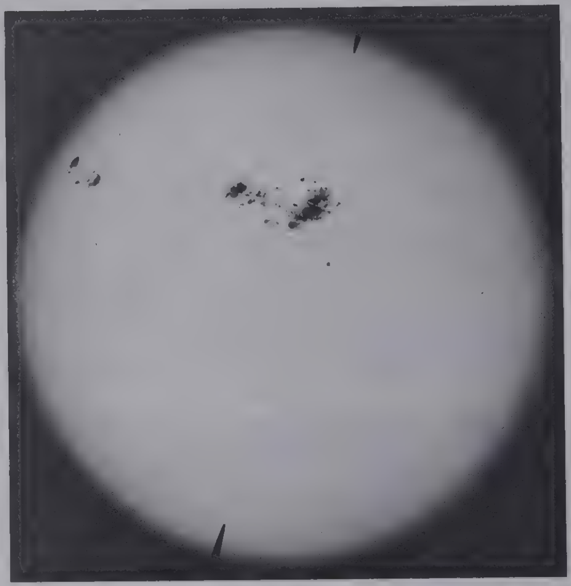
Activity 3:

How can sunspots be studied?

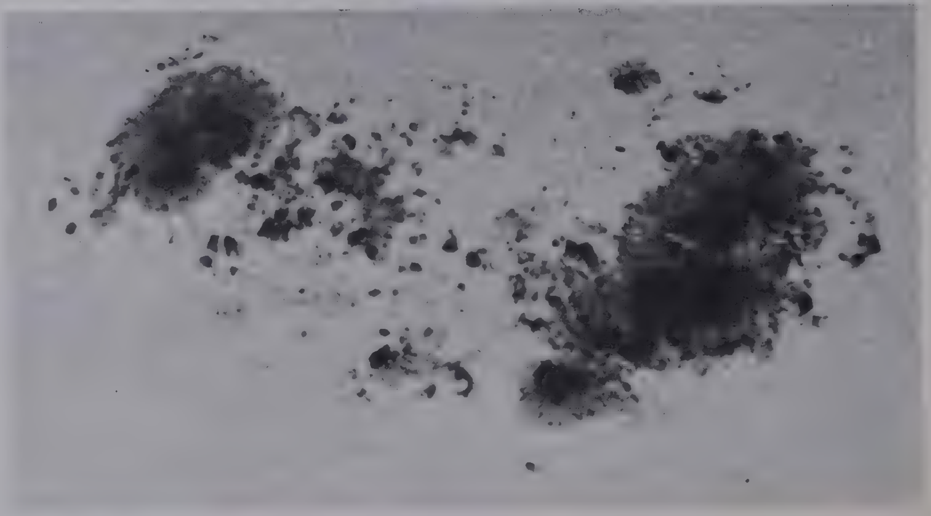
Sunspots have baffled scientists for many years. Sunspots appear as large, irregular, dark blotches on the surface of the sun. Such huge areas are covered that many earths could easily fit inside an average sunspot. Some of the spots are over 80 000 km in diameter. These dark spots on the sun seem to break out periodically with the maximum number of sunspots occurring in cycles of about eleven years. Man is interested in sunspots, since after sunspot-storms radio communications are disrupted.

The following activity will allow you to view sunspots for yourself. Gather together the following materials: a purse mirror, masking tape, and two 20 cm by 25 cm pieces of heavy cardboard. When doing this activity or any other activity with the sun, never look directly at it or shine the light from the mirror into someone's eyes; this could cause blindness!

Go outside on a bright, sunny day with a friend and the materials. Locate a spot which will allow you to tape one piece of cardboard to a fence or wall while still being able to reflect light with the mirror from the sun onto it. Using a sharp pencil or a nail, punch a small hole in the middle of the second piece of cardboard. Have your friend hold the cardboard between the piece taped to the wall and the mirror in your hand. Now reflect the sunlight through the hole in the first piece of cardboard onto the second piece of cardboard. A near-perfect image of the sun should result, and if the distance between the two pieces of cardboard is great enough, larger sunspots should be seen clearly as black specks.



A Sunspot of April 1947



Digging Deeper

Does a greater distance between the pieces of cardboard give a better image?

Does the size of the opening in the first piece of cardboard affect the image of the sunspots?

Does the opening have to be round?

Are the sunspots grouped together, paired, or single?

What shape are the dark blotches?

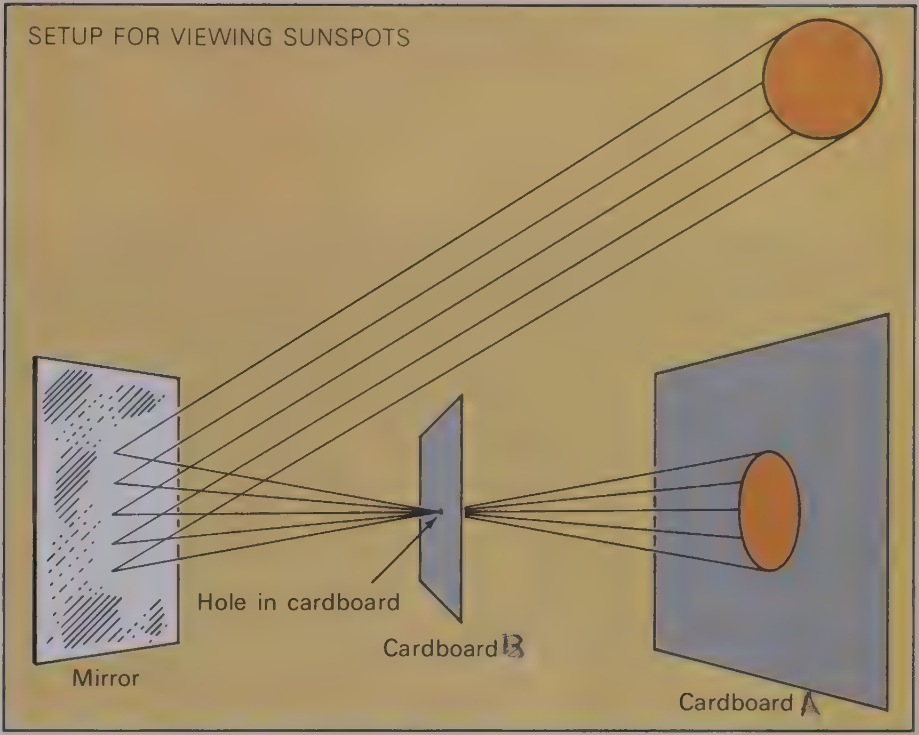
Has a sunspot the same degree of darkness over its entire area?

How could the location of sunspots be recorded?

Branching Out

An alternative and perhaps better method for viewing sunspots is to use a pair of binoculars, a support stand, and a piece of white Bristol board for a screen. Mount the binoculars on the stand so that the eyepiece points toward the sun. Do not look at the sun through the binoculars! Arrange the binoculars in such a manner that sunlight will pass through the binoculars and strike the screen. Move the screen back and forth until the largest, clearest image of the sun is obtained. Holding or fixing a cardboard collar around the eyepiece will aid in making a sharper image.

Repeat the foregoing activity for several successive days. On the first day draw a circle around the sun's image and mark on the sunspots. Note the



time and date. Each day thereafter repeat the procedure at the same time using the same piece of paper. Set the equipment up so that everything is nearly identical to the set-up on the first day you recorded the spots.

Mark the position of the sunspots for several days.

Are the sunspots moving? If so, in what direction? If the sunspots are indeed moving, what does that tell us about the sun?

Are the sunspots closer to the poles of the sun or the sun's equator?

What is a solar eclipse? Read in encyclopedias and science books to discover the answer. How do astronomers regard eclipses historically, chronologically, and astronomically.

Only one more solar eclipse will be visible to North America this century. This eclipse will occur on January 26, 1979. Exactly where will it take place? What path will it follow? What precautions should be taken if one is to watch this eclipse? Your local planetarium or science museum will serve you well when researching these particular questions.

If you wish to read an excellent and exciting story in which a solar eclipse plays a key role in the plot, visit your school or public library and borrow the book, *A Connecticut Yankee in King Arthur's Court* by Samuel Langhorne Clemens.

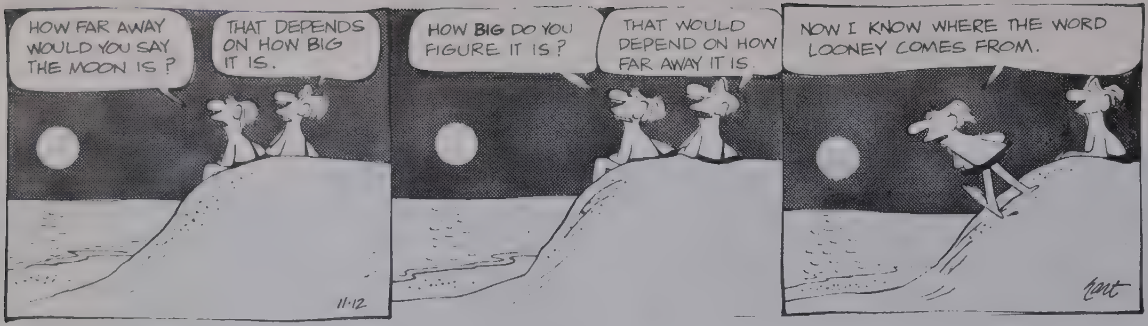
Which is the better method for viewing sun spots?

The solar eclipse of March, 1970.

The Moon

4

4. The Moon


B.C. By John Hart
HOW FAR AWAY WOULD YOU SAY THE MOON IS?
THAT DEPENDS ON HOW BIG IT IS.
HOW BIG DO YOU FIGURE IT IS?
THAT WOULD DEPEND ON HOW FAR AWAY IT IS.
NOW I KNOW WHERE THE WORD LOONEY COMES FROM.
11-12
hart

The second brightest object we see in the sky is our nearest neighbour in space, the moon. Because of its closeness and changing brightness man has been extremely interested in the moon from ancient times. His dream has been to actually visit this other island in space and determine just what the moon is. This dream has become a reality in our lifetime, for on July 16, 1969, man set foot on the moon. This was an historic event because for the first time man actually left his island home and crossed the dark, dangerous ocean of space. During the next few decades he will revisit the moon many times and study it in detail.

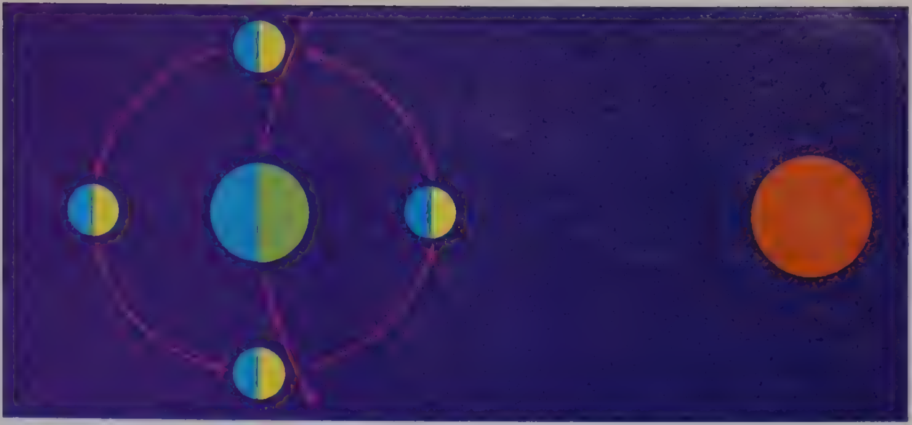
Astronaut Edwin E. Aldrin Jr. during Apollo 11 moon walk.

Activity 1:

What does the moon's orbit really look like?

Most people have the notion that the moon loops or revolves continuously around the earth. This concept of the motion of the moon is not entirely a true picture of what really happens. The moon, like the earth and other planets, is a prisoner of the sun and the moon goes around the sun, as the earth does. In fact, the moon's orbit or path curves inward to the sun. The moon's orbit can be illustrated on a large 175 cm square of paper

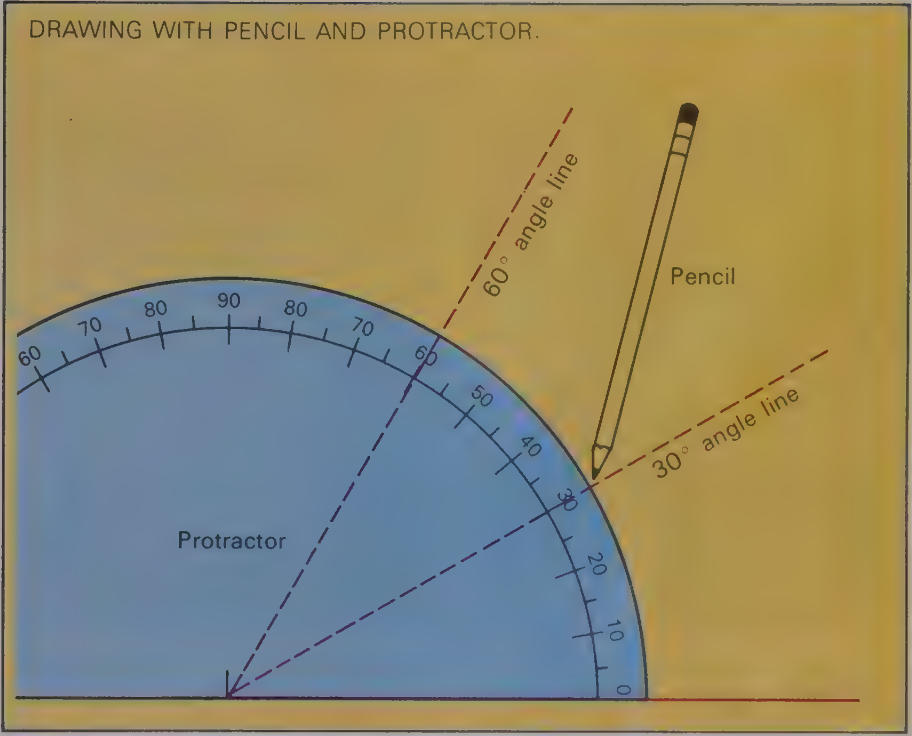
Does the moon ever go backward in its orbit?



by drawing a scale model of the sun, the earth, and the moon. Gather together large sheets of newspaper, a piece of string 175 cm long, a half-circle protractor, cellulose tape, a black felt marker, and a red pencil crayon.

Tape the newspaper together on the floor so that you have one large sheet 175 cm long and 175 cm wide.

Use a scale of 1 cm : 1 000 000 km. Let the sun be in the lower left-hand corner of the large sheet of paper. Using the red pencil crayon and the piece of string, fix one end of the string at the sun, and draw a curved line from the upper left-hand side of the sheet to the lower right hand side of the sheet. This quarter circle represents one quater of the orbit of the earth around the sun. It should be 2.0 m out from the sun since the earth is approximately 150 000 000 km from the sun.



Now take the half-circle protractor and center it on the sun so that the zero-degree line of the protractor is directly over the bottom edge of the piece of paper. The quarter circle contains 90°. Divide the earth's orbit into three equal parts of 30° each. Place small dots to represent the earth on the curved line at the 30° and 60° points on the curve. Connect these two points to the sun with a solid line. The lines should be labelled as illustrated.

Mark a dot at each end of the curved line also. Each of the three sections of the quarter circle stands for one month.

Using a lead pencil, divide the three 30° sections into four equal parts of 7.5° each. These divisions should be broken, not solid, lines. The 7.5° points along the earth's orbit represent the approximate position of one of the moon's phases: new moon, first quarter, full moon, and last quarter. The moon will be somewhere on one of these 7.5° divisions, but not necessarily on the earth's orbit; the actual position of the moon must be plotted. But first, place a black dot representing the earth at each of the 7.5° intervals along the earth's orbit.

Since the moon is almost 400 000 km from the earth, the dot representing the moon must be 4 mm away from the earth on the drawing. Beginning at the lower right-hand end of the earth's orbit and using a sharp lead pencil, draw a small circle with a 5 mm diameter between the earth and the sun. Since the moon is between the earth and the sun, the left half of the circle should be left while indicating that the sun is lighting it, while the right half of the circle should be shaded black indicating that it is receiving no light from the sun.

Proceed up the earth's orbit to the next black dot. Draw a second circle with a radius to represent the moon (5 mm) directly below the dot. Shade in the circle correctly.

Continue up the curved line to the next black dot representing the earth. Draw another small circle directly behind the earth so that the earth is between the sun and the moon. Shade the circle as before.

At the next black dot up the curved line, draw the small circle for the moon above the dot, but on the curved line. Shade the circle as before.

At the fifth black dot from the bottom of the sheet of paper, draw the small circle between the earth and the sun again.

Now you have completed one *lunar month,* or one pattern of the phases of the moon. Continue this procedure for the remaining two months on your chart. You will find that this series of phases repeats itself. When all the positions of the moon have been plotted on the chart, join them with a dotted red line.

Digging Deeper

The moon has basically four phases: new moon, first quarter, full moon, and last or third quarter. The new moon usually cannot be seen because, at that particular point in the moon's orbit, the moon is between the earth and the sun, and the lighted surface is toward the sun and is not visible from the earth since it is a black moon in a black sky. At first and third quarter moons, the moon is at right-angles to the earth. When the moon is full, the earth is almost between the sun and the moon and as a result observers from the earth see a full-lighted surface. Using this information and the moon's positions as plotted on your scale model, label the phases of the moon correctly for each month.

Look at the model drawing of the moon's orbit. Does the moon loop around the earth?

Does the moon go around the earth? Explain.

Does the moon go around the sun?

Look up the meaning of the words, *revolve* and *rotate*. Does the moon revolve, rotate, or both?

If the new moon is located between the earth and the sun, would it be in the daytime sky or night-time sky?

To an observer on earth, why does the moon have phases? Use your scale model and discuss this question.

To an observer on the sun, would the moon have phases?

Approximately, how much of the moon's surface is lighted at any one time?

If you were to tape three more 175 cm square sheets of paper to your original so that you had a larger square of paper, you could plot the lunar orbit for one full year. How many complete phases of the moon would occur?

How could you check on your answer?

Do we see all sides of the moon?

Branching Out

What is a *synodic month?* a *sidereal month?*

Why is the earth-moon system called, or referred to, as a two-planet system?

In your scale drawing of the moon's orbit you placed the moon 60 cm from the earth which, according to the scale used, would really be 390 000 The distance to the moon was calculated in the 18th century and a distance of roughly 380 000 km was obtained. In the 1940's, just after the Second World War scientists in the United States measured the distance to the moon with radar. Radar waves travel at approximately 300 000 km/s. The experimenters bounced a signal off the moon and recorded the time it took the signal to go to the moon and return to earth. The round trip took only 2.6 s. Calculate the distance to the moon using this information. Who were the first men to measure the distance? Is the distance between the earth and the moon constant?

In the 1960's, American scientists measured the distance to the moon using a special form of light. They bounced a light beam off the moon in much the same way as the radar beam was used. What did they calculate the distance to the moon to be? Did the Apollo astronauts measure the distance to the moon during any of their trips to the moon?

The earth's diameter is only 13 000 km. Cut out, from heavy cardboard, a circle with a 2 cm diameter. Let this disc be the earth. If you were to cut out a disc to represent the moon, what should the diameter of this disc be? Cut it out. The scale you are now using is 1 cm : 6500 km. How far away should the smaller circle be placed from the larger one in order to create a scale model of the earth-moon system?

Activity 2:

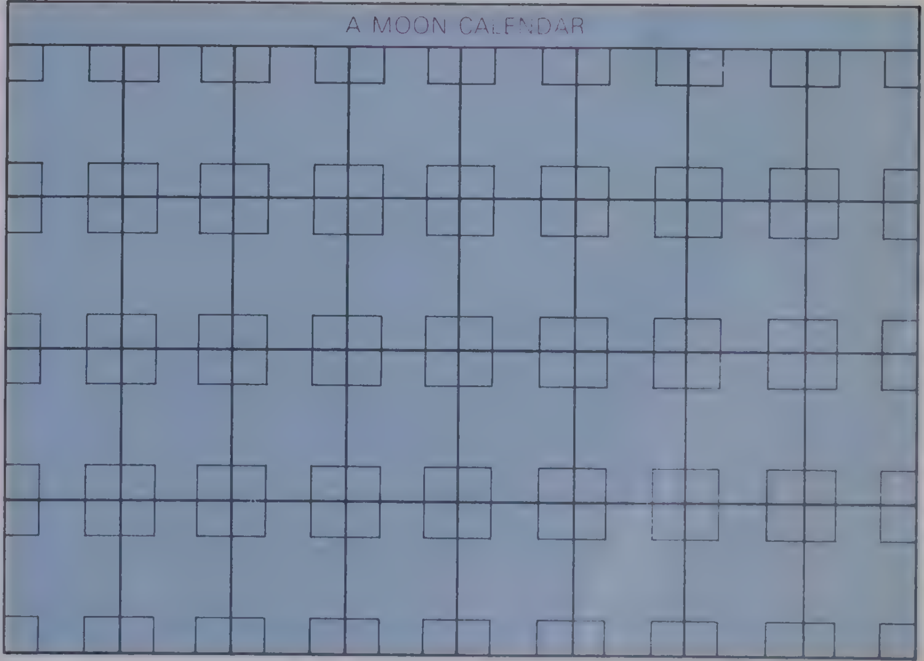
How can the phases of the moon be recorded on a moon calendar?

Man's observations of the moon appear early in recorded history. He observed that the phases of the moon were extremely regular, always taking the same amount of time. By keeping careful watch on the cycle of the moon, man could regulate his life; he had a timepiece, or clock. Because of this, the motions of the moon became of great importance to man. He observed the moon faithfully and recorded all of its movements until he could predict ahead of time where the moon was going to be. By keeping a moon calendar for a few months one can learn a great deal about the moon and its travels through the heavens.

For this activity, you will need your astrolabe from Chapter 1 (see page 9) a commercial calendar which tells you the date of the next new moon, a lead pencil, a ruler, a penny, and a large sheet of paper.

Prepare your moon calendar by dividing the sheet of paper into 32 2 cm x 4 cm boxes. Leave room at the top of your calendar for your name and a title. There should be 8 boxes along the top and 4 boxes down the side. Refer to the following photograph of the moon calendar for a

'Goodness, Harry! What's so exciting about a quarter moon?'

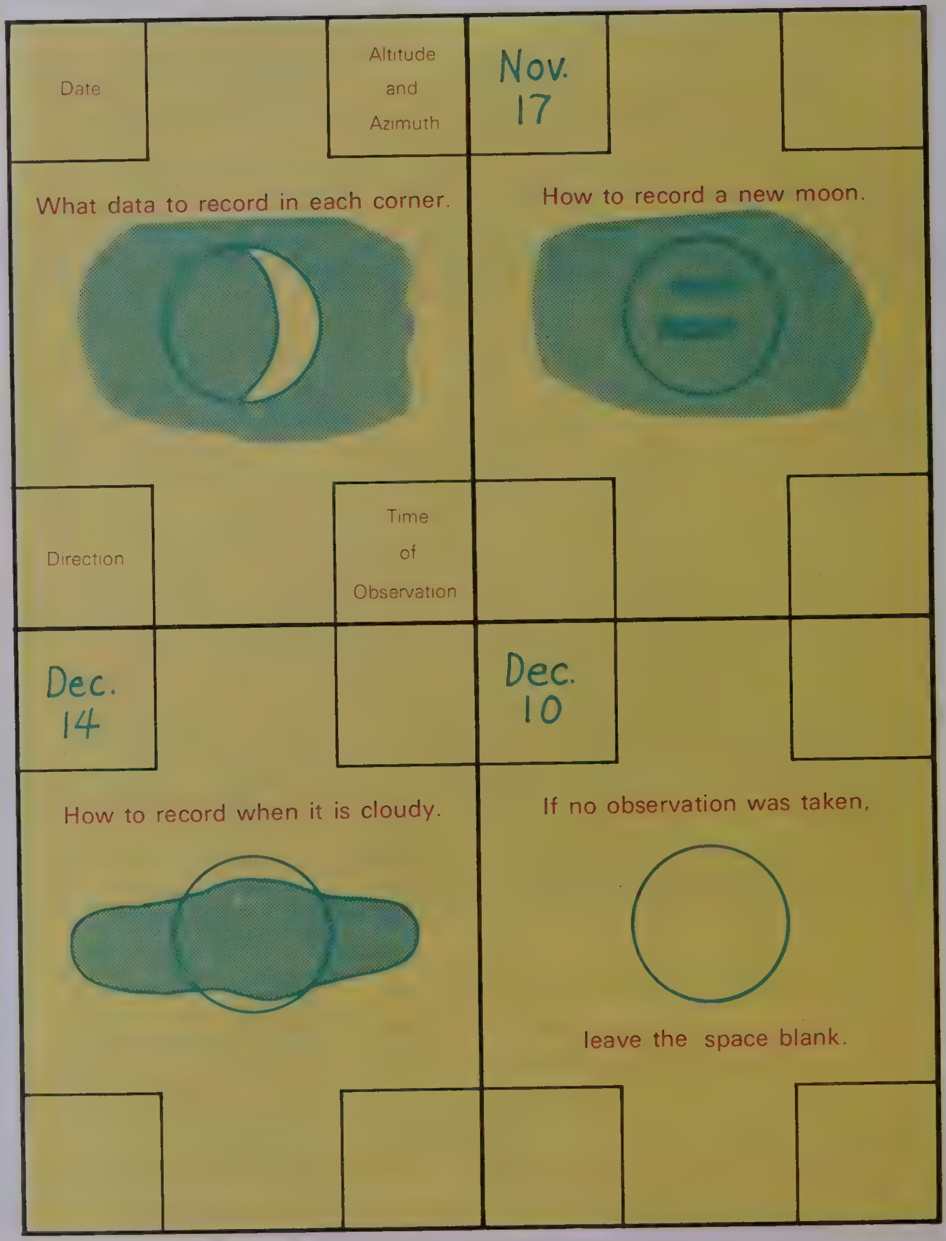


proper frame of reference before you begin to draw.

Using the penny as a guide, draw a circle in the center of each space. Be sure that the coin is properly centered before inscribing the circle since you will need room in each corner to record the data. These circles will act as a pattern for you when you are actually sketching the phase of the moon seen in the sky. All you need to do is draw one line within the circle which will give you the correct shape for your observation.

When you are drawing the moon's shape on white paper, you should color in the area immediately surrounding the lighted portion since the moon appears bright in the black sky.

The starting-point and end-point of your moon calendar will both be new moons. Refer to the calendar to determine the date of the next new moon. Put the date in the upper left-hand corner of the first space. Continue along to each successive box putting the appropriate date in the upper left-hand corner of each. For example, the new moon for November 1971 arrives on the 17th; consequently November 17 should be placed in the corner of the first box, November 18 in the second box, and so on, up to the date of the next new moon which, in this case, is December 17. The moons in both November 17 and the December 17 boxes should be labelled ''New Moon'' and be completely shaded since the moon is invisible to an observer on the earth during that particular phase. Refer to the sample illustrations to get an idea as to how to record your data accurately on the calendar. The commercial calendar will also give


Date
Altitude and Azimuth
Nov. 17
What data to record in each corner.
How to record a new moon.
Direction
Time of Observation
Dec. 14
Dec. 10
How to record when it is cloudy.
If no observation was taken,
leave the space blank.

Why does the moon appear to have different phases?

you the date, of the first quarter, full moon, and last quarter; these labels should be printed on the appropriate moons also.

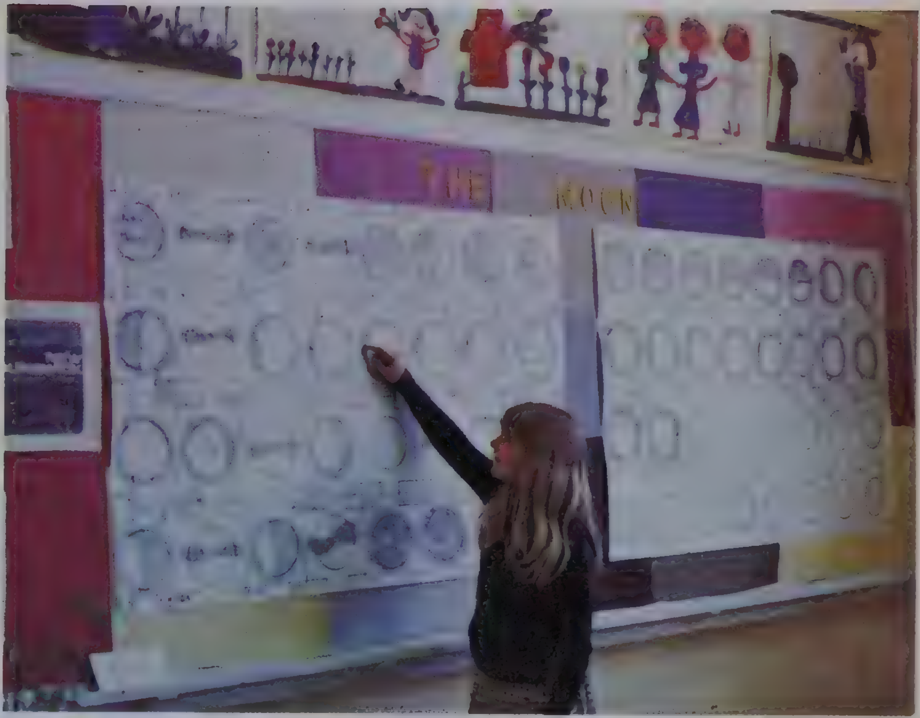
The remaining three corners of each space should contain the following information.

The upper right-hand corner should contain data on the moon's azimuth and altitude. See Chapter 1, page 7 if you have forgotten these two terms. You must use your astrolabe to obtain these measurements.

The bottom right-hand corner should contain the time of your observation. Since the moon is visible in the day-time sky as well as the night-time sky you will need to record the time carefully from your 24 h clock.

The lower left-hand corner should hold data regarding the moon's direction during any one day. For instance, suppose you went out and observed the moon at 20:15 and the azimuth was 230°; then you went out 30 min later, at 20:45 and the azimuth was now about 238°. The entry in the lower left-hand corner read 230° to 238°. This observation gives you the apparent motion of the moon.

Two other items regarding daily or nightly observations should be mentioned here. If the sky is overcast or cloudy and no moon is visible, draw



Why must the astrolabe be level before taking a reading?

a cloud over the face of the moon for that day and shade it in. Secondly, if for some reason you were unable to take a moon reading, or you forgot, just leave that day blank.

Probably the best time to begin your moon calendar would be in the late autumn or early winter. Darkness comes early at this time of year making observations convenient. If you do not see the moon at night, check the morning sky before you go to school. Remember, if you observe the moon in the morning sky, that will be the reading for the previous evening. You should attempt faithfully to obtain a reading for each day since a calendar with many blanks will unlock very few of the moon's secrets. If other people are doing a moon calendar or the class is doing one, check with them in order to obtain any readings you have missed. When you have completed one cycle of the moon's phases you could start a second moon calendar. The more data you collect on the moon the better you will understand and appreciate it.

To actually begin recording your observations on the moon calendar begin watching the western sky just after sunset on the dates directly following a new moon. The appearance of a thin crescent will mark the beginning of a new lunar month. After you have collected your data on the moon for one or two months, attempt to answer the questions in the Digging Deeper section using the data from your moon calendar.

Digging Deeper

How long after sunset does the new crescent moon set?

How many days did it take the moon to go from new moon to new moon?

How many days passed between the new moon and the first quarter?

Are there always the same number of days between phases?

On your chart, is the left or is the right side of the moon lighted before a full moon occurs? What side is lighted after a full moon?

During what stage of the cycle is the moon seen at night? in the morning?

In what part of the sky is the crescent moon? first quarter moon? full moon?

In what direction does the moon appear to travel during any one night?

In what direction across the sky is the moon actually travelling during its entire cycle.

During what phase is the moon visible in the sky for the longest period?

Why?

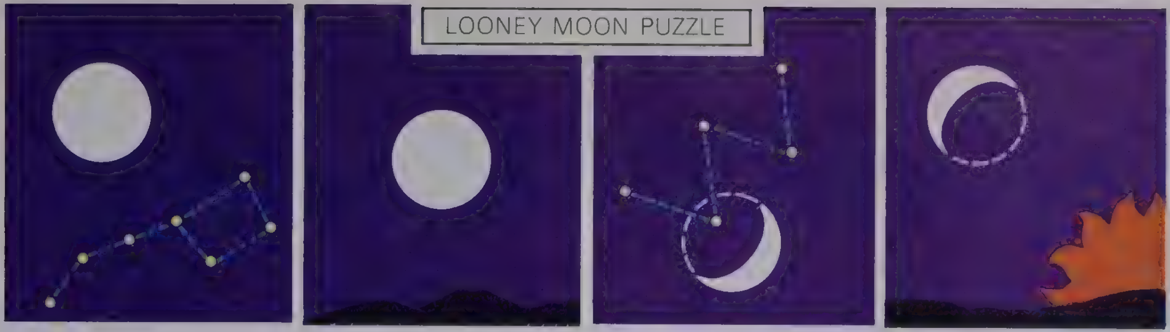
Does the moon really change shape?

Does the altitude of the moon or its angle above the horizon change each night?

Does the moon rise at exactly the same time each night?

What actually causes the moon to have different phases?

Consider the following. From the western to eastern horizon measures 180° and the new crescent moon appears in the west and the full moon



in the east. In how many days does the moon travel from the western part of the sky to the eastern part or from new moon to full moon? Through how many degrees does the moon travel along its orbit each day in order to go from west to east in that number of days? If the moon travels that number of degrees, each day, how much later in minutes must it rise and set each night. Hint: 15° corresponds to 60 min.

How many days does the moon spend in the night-time sky? the daytime sky?

Is there a part of the sky in which the moon is never seen?

How many days is the moon invisible in the sky?

How many nights does the moon stay full?

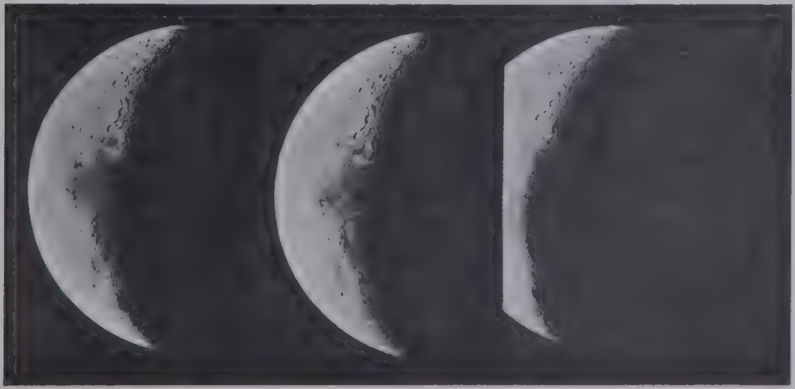
Branching Out

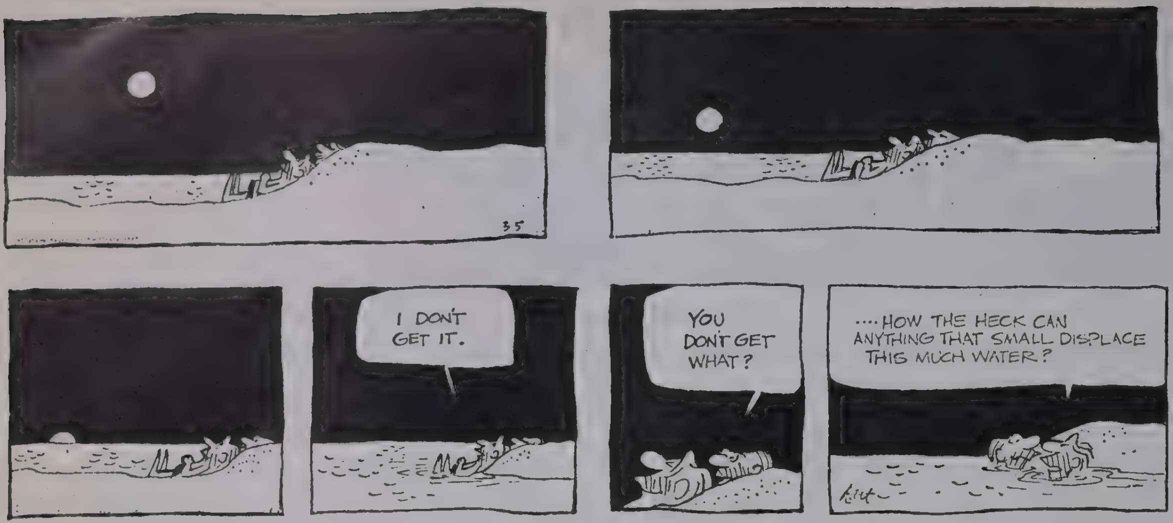
What is a harvest moon? hunter's moon? waxing moon? waning moon?

Try to answer the following moon puzzles using your collected information and your own knowledge of the moon. Examine each picture and identify the positions which could never occur. Explain why in each case you believed the moon's position to be impossible.

The moon and tides are related. Read in books to discover what the relationship is.

Some night when the moon is full, watch it moving against the background of stars. Pick a star which is near the center of its western edge and time, with a stop watch if one is available, how long the moon takes to travel its own width. The time will be up when the star reappears on the eastern edge of the moon. How long was the star out of sight? What is the moon's diameter? If you know the moon's diameter and the time it took to travel its own width, at what speed in km/h does the moon travel along its path or orbit? What does the word *occulation* mean?





B.C. © 1967 by Publishers Newspaper Syndicate By Johnny Hart

I DON'T GET IT.
YOU DON'T GET WHAT?
.... HOW THE HECK CAN ANYTHING THAT SMALL DISPLACE THIS MUCH WATER?

Activity 3:

How can a simple telescope be constructed?

Buying a simple telescope kit is an excellent way of building your own telescope. A kit can be purchased for approximately $3.00 from:

Edmund Scientific Company
555 Edscorp Building
Barrington
New Jersey 08007, U.S.A.

One of the most rewarding experiences you can have in your study of astronomy is to look at the heavens through a telescope. Because of a telescope's light-gathering ability, details not visible to the unaided eye are revealed to you. Mountains, craters, and plains show up clearly on the moon. Saturn's rings become realities and four of the moons of Jupiter are easily identified. Galileo, an Italian scientist, was one of the earliest users of the telescope to explore the heavens. He ground his own glass to make lenses which he mounted in a long narrow tube. Galileo succeeded in constructing a telescope that could make objects appear thirty times larger than their real size.

This will give you an 8-power telescope.

Two of Galileo's original telescopes.

Galileo.

With this telescope Galileo was the first to see mountains on the moon, four of Jupiter's moons, Saturn, the phases of Venus, and sunspots.

You can follow in Galileo's footsteps by constructing your own simple telescope. You will discover first-hand what Galileo found over 360 years ago.

To construct your own telescope, you will need to obtain: a long heavy cardboard tube such as a mailing tube; masking tape, scissors; a fast-drying glue such as the type used in building models; and two lenses, one of short focal length and the other of long focal length. The term focal length is complicated and it is not necessary to understand its meaning in order to successfully build a telescope. Your most difficult task will probably be in obtaining the lenses. A war surplus store might have lenses but, if not, ask your teacher or a high school physics teacher where the lenses can be purchased. The high school physics teacher will also be able to advise you on the whole operation. The lenses are the heart of your telescope.

Once you have two lenses of different focal lengths, you must use them in

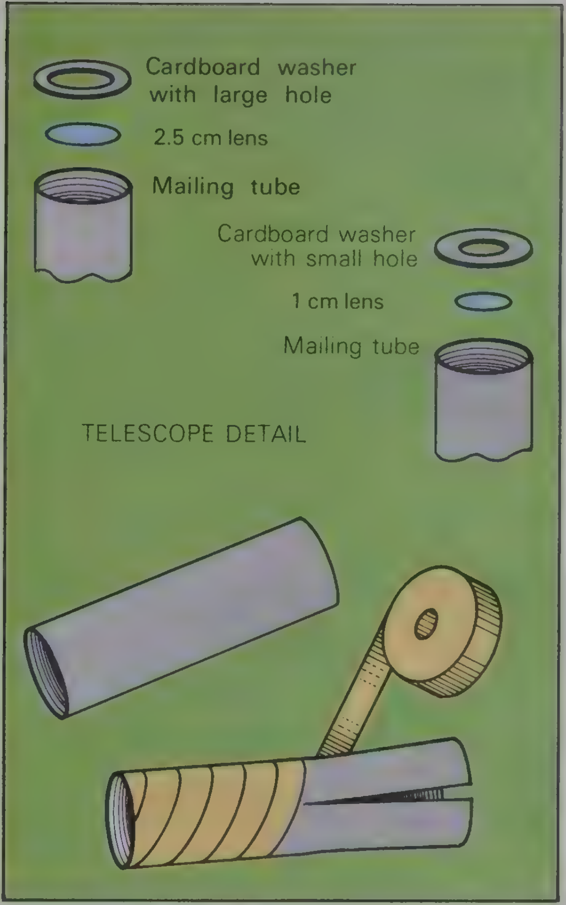
An assembled 8-power telescope.

combination to determine how long a tube you require. This can be done by holding the smaller lens near your eye and the larger one at some distance, but with both lenses in line. Focus on an object quite distant from you and move the larger lens back and forth until a clear, sharp image of the object is formed. While holding the lenses in this position have a second person measure the distance between each of the lenses. This measurement is the minimum length required for the tube of your telescope.

Cut the mailing tube into two cylinders of equal length. Take one of the cylinders and slit it straight down one of its sides. Remove a strip of cardboard from the slit cylinder so that when it is pressed together, closing the slit, it will just slide easily in and out of the uncut cylinder. Wrap masking tape around the full length of the cut tube to keep the slit closed and to make a closer fit between the two tubes.

Now the lenses must be mounted on the tubes. The larger lens goes on the end of the larger tube and the smaller lens goes on the end of the smaller tube. The lenses must be fixed securely and evenly. This is achieved through the use of two cardboard washers. The diameter of the cardboard washers should be greater than that of the tubes. The washer for the smaller lens should have a 5 mm hole punched out of its center with a sharp pencil. Put some fast-drying glue around the 5 mm opening and place the center of the small lens squarely over the opening in the washer. Make sure no glue gets on the lens. When the glue dries, apply more glue between the lens and the cardboard and let it harden. The larger lens can be mounted to a cardboard washer in exactly the same way, except the window opening in this washer should be as large as possible, leaving only enough cardboard to glue the lens onto it. Next, glue the cardboard washers with their lenses onto the end of the telescope tubes.

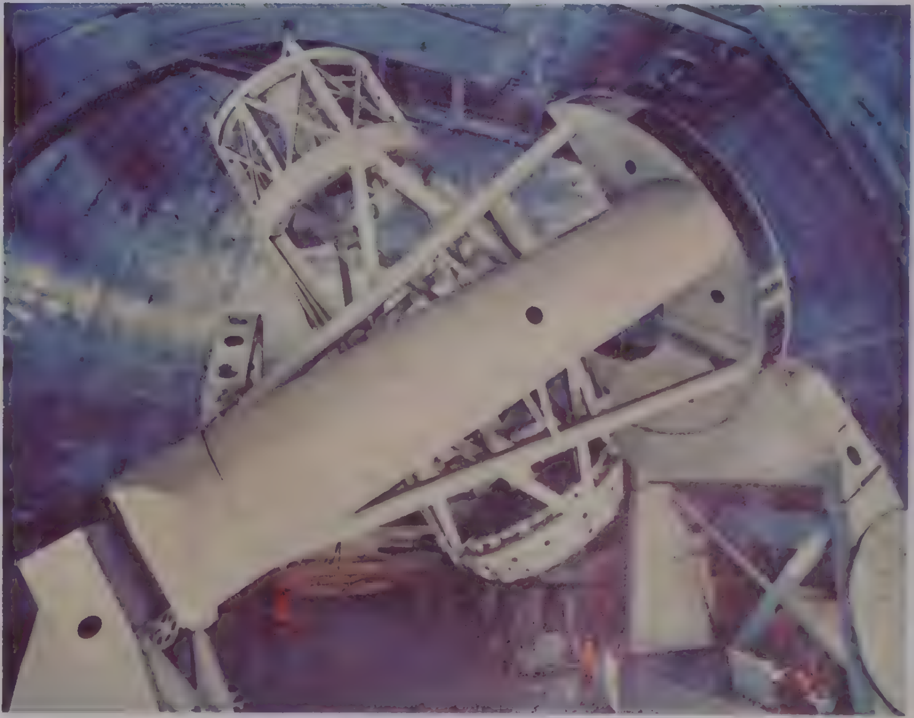
After your telescope is assembled, try it out on objects around the room and then, objects outside. Move the two tubes in and out until the sharpest image possible is obtained. The next activity in this chapter, Activity 4, suggests some worthwhile uses for your new telescope.


Cardboard washer with large hole
2.5 cm lens
Mailing tube
Cardboard washer with small hole
1 cm lens
Mailing tube
TELESCOPE DETAIL

Digging Deeper

Which end of the telescope should you look through when viewing distant objects like the moon and stars? What happens when you look through your telescope from the larger end? Does a telescope need a tube? What purpose does the tube serve?

Locate the telescope in this picture. Does it have an enclosed tube?



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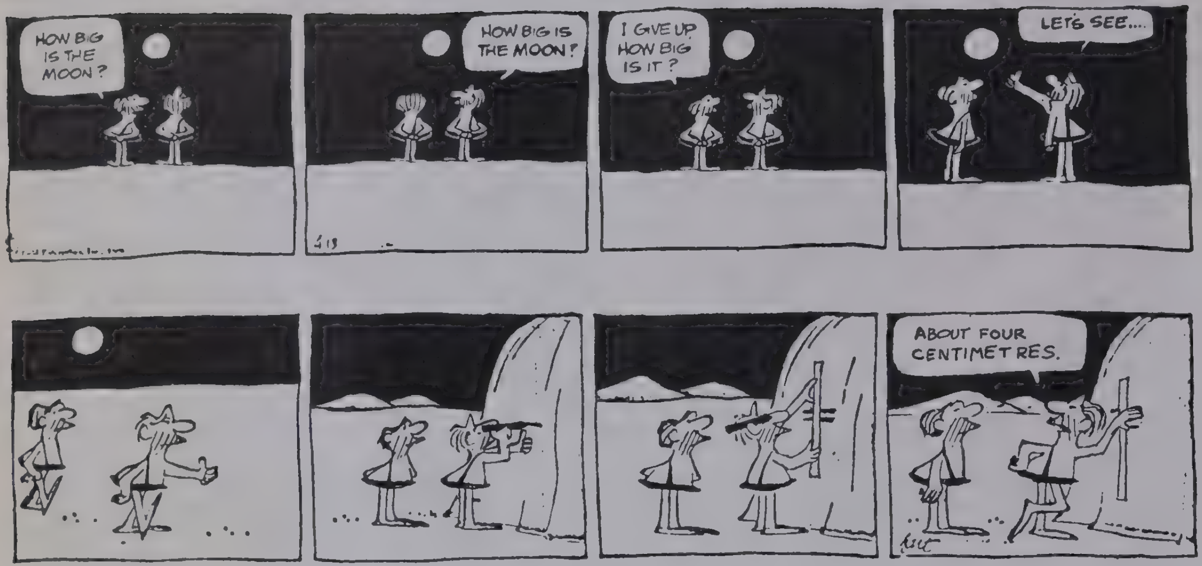

HOW BIG IS THE MOON ?
HOW BIG IS THE MOON ?
I GIVE UP. HOW BIG IS IT ?
LET'S SEE....
ABOUT FOUR CENTIMETRES.

Branching Out

Read to discover what type of telescope you have made.

Make up a scrap book of how and where each telescope is used and explain how one telescope is different from another.

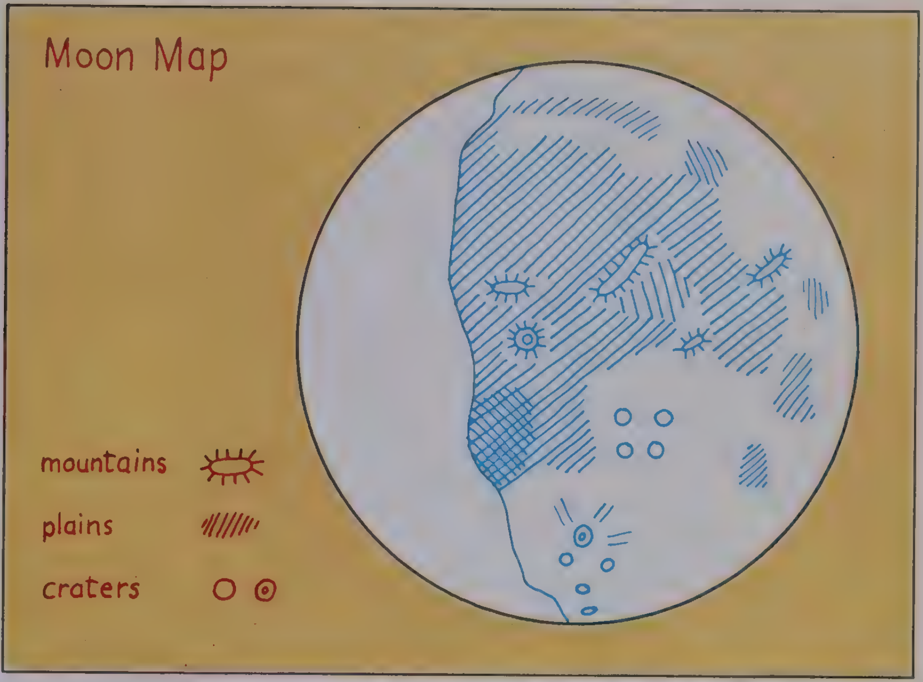
What other types of telescopes are there?

Galileo only improved on the telescope. Who invented it?

Find the magnifying power of your telescope. This can be done by drawing a grid on the chalkboard. From the back of the room look through your telescope at the grid on the front chalkboard. The squares in the grid should be large enough that you can easily count them without looking through the scope. Now practice looking with one eye through the scope at the grid and at the same time looking at the grid with your other eye. You may find this difficult to do the first few times you try but do not be discouraged.

Once you have mastered the technique of keeping both eyes open, you will be able to see the two different sizes of square side by side. To determine the power of your telescope, count with your unaided eye, the number of squares equal in height to one large square as magnified by the telescope. If it takes 10 squares on the grid to equal one magnified square, the telescope increases the size of the object by 10 diameters. The telescope is described as being of 10 power.

Search through magazines and books to obtain pictures of the different types of telescopes which have been invented.



Activity 4:

How can a map of the moon's surface be made?

When Galileo made his own telescope, the first object he studied in the sky was the moon. This was logical, since it is the largest, brightest, closest, and most easily seen celestial body in the sky. The moon should be your first object of study when using your telescope. Galileo observed the moon along the line separating the dark and lighted portions of the moon. This line is called the terminator line. This method is still used today since all moon features found along this line are sharper and clearer than in any other place on the moon.

The best time to begin mapping the moon's surface is one or two days after a new moon. Begin by mapping the features along the terminator line of the crescent moon. Wait a couple more days and map again. Use your own symbols to represent mountains, craters, and plains. Continue this procedure for approximately two weeks until you have mapped the entire visible half of the moon. If you are really a keen moon mapper you could draw some of your moon map each night until the full moon.

Your moon map should indicate only major features of the moon's surface such as mountains, craters, and plains; do not attempt to include too much on your map. Once your map is completed, or after each mapping session, use a book on the moon containing a labelled map to guide you in the labelling of your map. An excellent map of the moon is available for only 35 cents from the following address:

Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20301, U.S.A.

A great aid to drawing a continuous map of the moon's suface is graph paper with 1 cm squares. The largest possible circle drawn on the graph paper can represent the moon. The lines of the grid will help you map the features observed.

An alternative to drawing a continuous map would be to draw a new map each night the moon is observed. Begin by marking in the terminator line first.

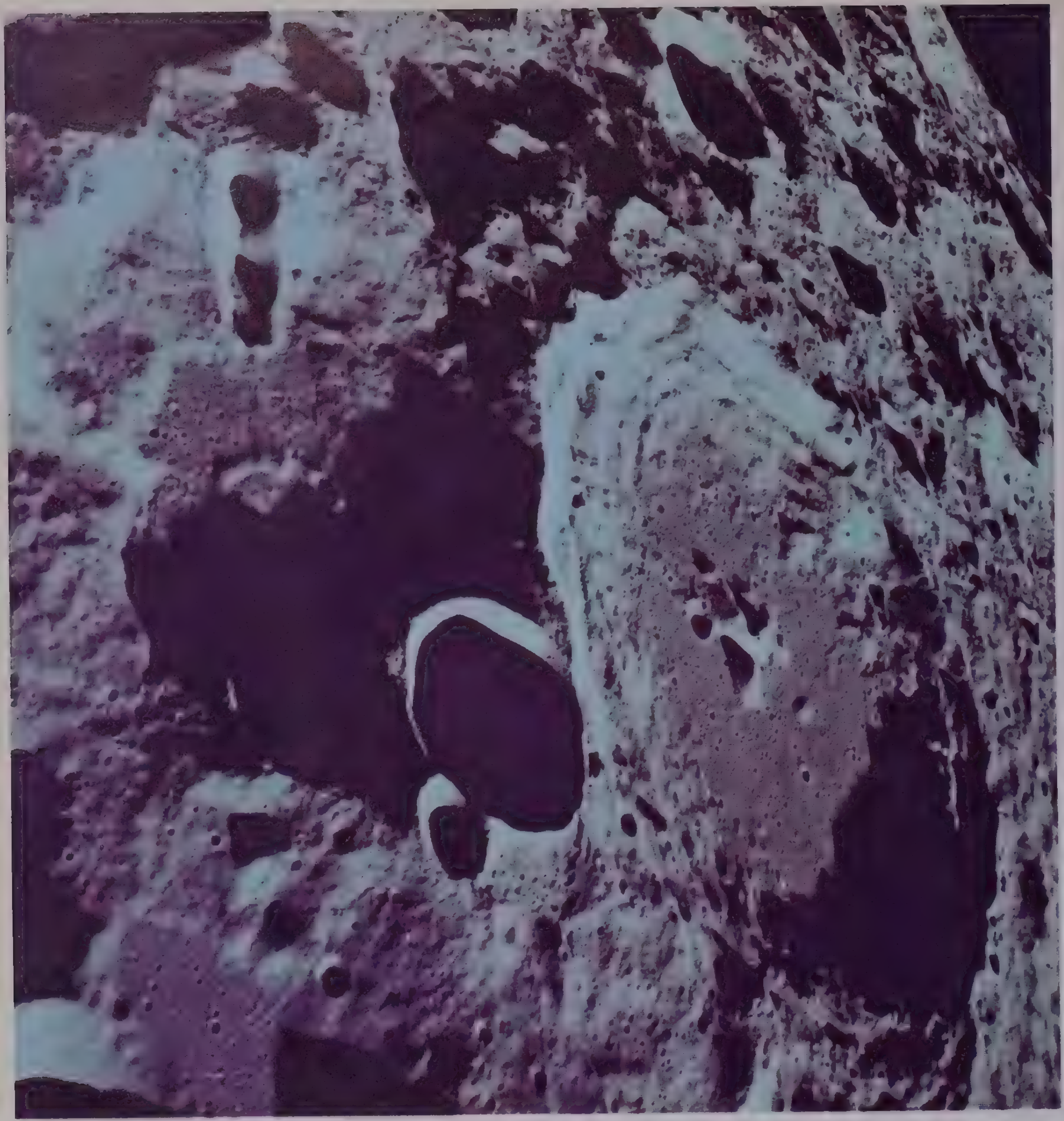
Digging Deeper

What are the dark patches of the moon?

What are the lighter patches of the moon?

Does the position of the terminator line actually change?

What is Selenography?



What phase of the moon would be the poorest time to observe the moon with a telescope? Why?

Branching Out

Where on the moon did the Apollo XI spacecraft, Eagle, land? Can you locate this area on the moon with your telescope?

What is a *gibbous moon?*

Do astronomers map the moon's features the way you have just done or is some other method used?

What is *selenography?*

Examine the photograph of the moon's surface. The surface is marred by many craters. Scientists feel that the huge holes on the moon's surface are caused mostly by meteors hitting the moon; a few holes are due to volcanoes on the moon. You can make a model of the moon's pitted surface

What things have shaped the moon's surface?

by mixing some soil and water together to form mud. Put some of the mud on a plate in a smooth layer. Create the moon's uneven surface by dropping more mud onto the mud on the plate.

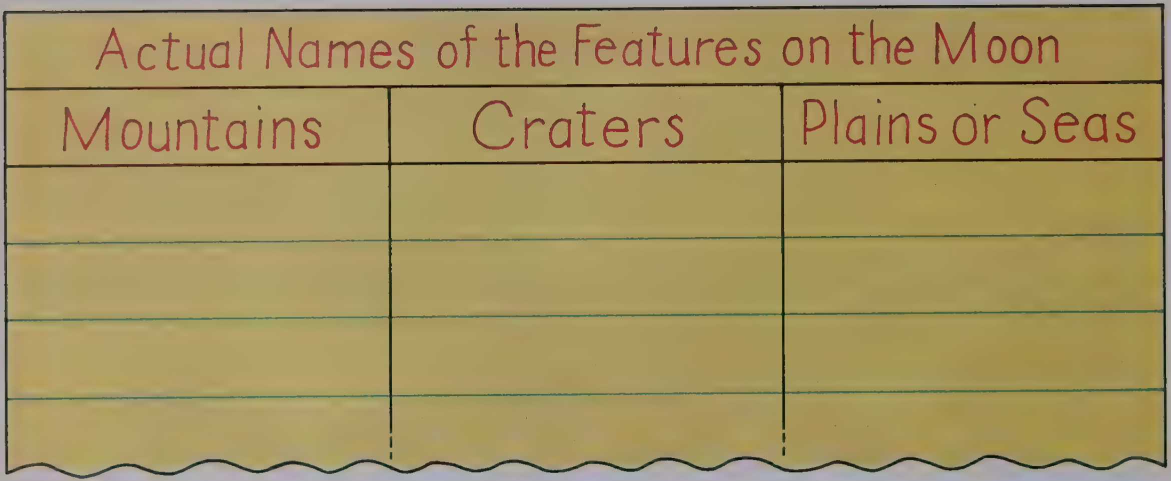
The three main features on the moon are mountains, craters, and plains or seas. Astronomers from the earliest times have named these outstanding features in a definite way. Modern astronomers belonging to the *Commission on Nomenclature for the Moon of the International Astronomical Union* have recently reaffirmed the earlier astronomers' way of naming lunar geographic features. This Commission must approve all new names that are put on official moon maps. To discover the secret of how the lunar features are named you will need two items: a good map of the moon with the features named and a chart such as the one illustrated. List the names of the major or largest features under each heading in your chart.

Once you have completed a list of ten names in each column, stop and look at them. Can you see what each of the three features is named after? Read to answer the following questions. Who is Johannes Hevelius? Who is Giovanni Riccioli? What system of classification for lunar features did Dr. D.H. Menzel of Harvard University suggest? Who began naming lunar features?

Another interesting activity is studying the people after whom features on the moon have been named. Set

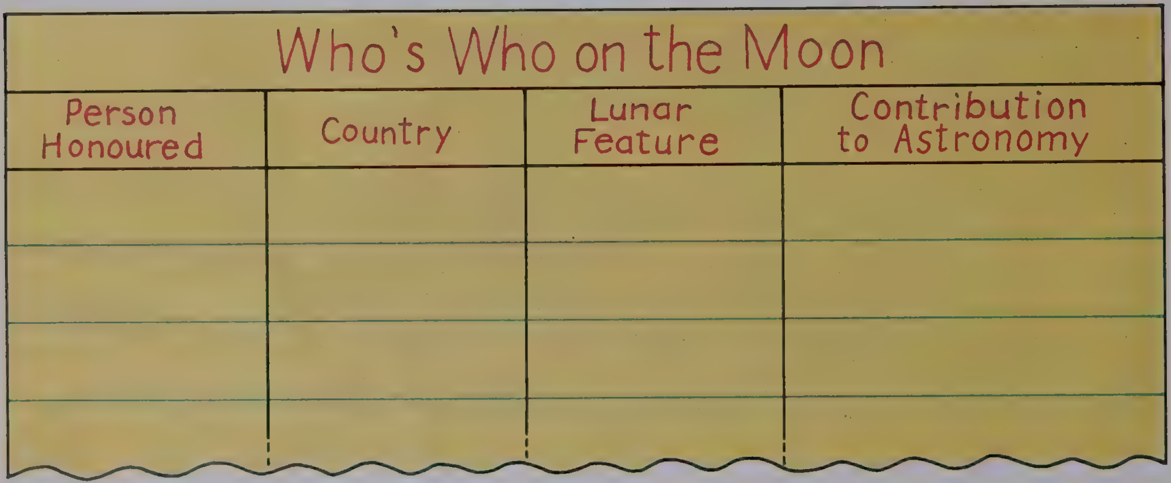
THE WIZARD OF ID
By Parker and Hart
YOU MADE AN ERROR ON THE LUNAR ECLIPSE... A MISTAKE IN CALCULATING THE RELATIVE SPEED... A VALUE TO THE FIFTH POWER, RATHER THAN CUBED.
IMPOSSIBLE!... IF THAT WERE TRUE, WE WOULD BE IN TOTAL DARKNESS AT THIS VERY MOMEN.....
7-7
...TO THE FIFTH POWER, YOU SAY?

By permission of John Hart and Field Enterprises Inc.



Actual Names of the Features on the Moon

Mountains	Craters	Plains or Seas



Who's Who on the Moon

Person Honoured	Country	Lunar Feature	Contribution to Astronomy

up a chart as follows. Select some names which are familiar to you and some which are not.

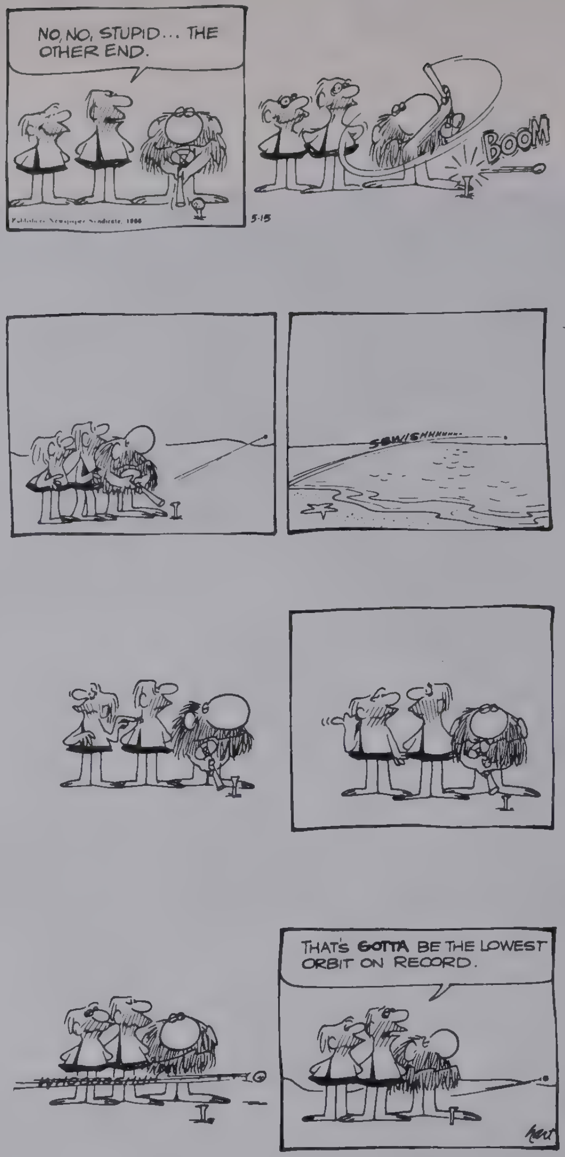
Obtain a copy of the *Farmer's Almanac* and read some of the superstitions about the moon. Discuss the validity of such sayings as "A halo around the moon is the forewarning of a storm" and "When the horns of the moon are very sharp expect only dry weather". What does the *Farmer's Almanac* say about planting certain plants according to the phases of the moon?

All In The Family

5

5. All In The Family

B.C. by John Hart


NO, NO, STUPID... THE OTHER END.
BOOM
5-15
SSWISHHHH....
WHOOOOSHHH
THAT'S GOTTA BE THE LOWEST ORBIT ON RECORD.
hart

By permission of John Hart and Field Enterprises, Inc.

The first chapter of this book gave you a frame of reference for observing the sky above. This last chapter will attempt to give you one last frame of reference about a topic that everyone knows at least something about – our solar system. There probably isn't anyone who has not heard of the sun and its nine captive planets. Actually, the sun has more prisoners than just the planets. Among its other captives are asteroids, comets, meteors, and the 31 satellites of the major planets such as the earth's moon. All of these celestial bodies make up the sun's family. How this strange planetary system was formed is still mysterious. Many theories have been put forward to explain how the sun's family came to be.

Most of us have a picture in our mind of the general nature of the solar system: a great, massive sun with the planets strung out from it like beads in a straight line. We could even attempt to create a scale model of it which would show the distances between the planets. However, these distances are meaningless and in fact do not really exist since the whole solar system is constantly in motion; nothing in the system is fixed, not even the smallest particle of dust. We need a frame of reference to give us a truer picture of the solar system.

The main idea you should understand about the solar system is its emptiness. Looking at models and pictures of the system in museums and books leads one to believe it is an overcrowded place. A traveller, upon first approaching our solar system, would probably see only the sun. The area around this star would appear empty and black except for the odd speck of matter here and there. In fact the solar system is almost empty of any solid matter.

In the activities which follow in this chapter there will be only a brief

The orbit of a planet around the sun is an ellipse, with the sun at one focus.

encounter with some member of the sun's family. The main emphasis will be placed on actually locating some of the planets in the sky. Only by doing this, and seeing for the first time another planet, will you really begin to appreciate your position in the solar system, and, perhaps, the universe.

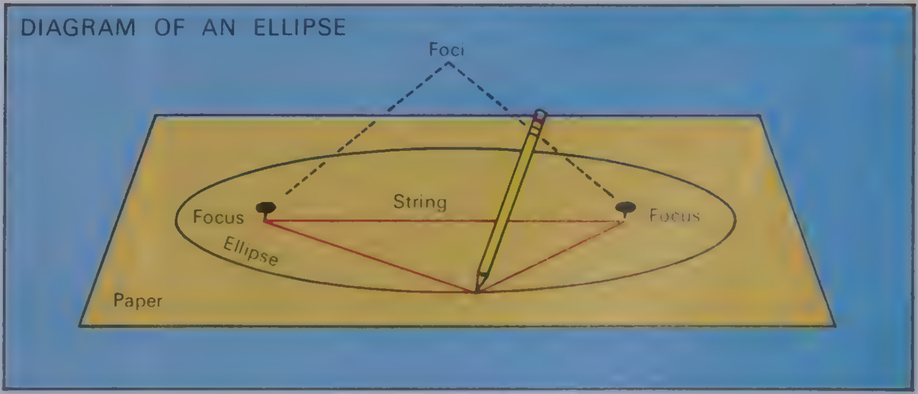
Activity 1:

How can the path or orbit of a planet around the sun be drawn?

The planets are really prisoners of the sun's gravity and as a result they travel around the sun in a closed path or orbit. Early astronomers, such as Ptolemy, believed that the earth was the center of the universe and everything in the heavens travelled in perfect circles around the earth. Later a Polish astronomer, Copernicus, developed a more accurate picture of the solar system. He placed the sun at the center with the planets orbiting the sun in perfect circles. Still later, another astronomer, Kepler, using the observations of Tycho Brahe, described accurately how the planets move through space. Kepler developed three laws later known as *Kepler's Laws.* The first law governing planetary motion states: *The orbit of a planet around the sun is an ellipse, with the sun at one of the foci.*

Draw some ellipses using the following materials: a sharpened pencil, a piece of heavy cardboard, two thumbtacks, several sheets of white paper to cover the cardboard drawing board, a straight pin, and some string tied into a loose loop.

Place the paper on the cardboard and insert two tacks about 7.5 cm apart near the center of the board. So that the string can pivot on them, do not push the tacks all the way into the cardboard. Take the loop of string and place it over the tacks, and then, stretch it as tight as possible with the pencil point. The straight pin can be pushed into the lower end of the pencil just above the lead to prevent



the string from slipping off. Draw a figure by moving the pencil around the inside of the loop. The figure that results will be an ellipse. Draw several more ellipses with the same loop, varying the distance between the tacks each time.

Digging Deeper

Where is the center of an ellipse?

If the sun is at one focus of the earth's ellipse what is at the other focus?

Does the moon move about the sun in the same way as the planets? What is different about a planet's motion compared to that of the moon?

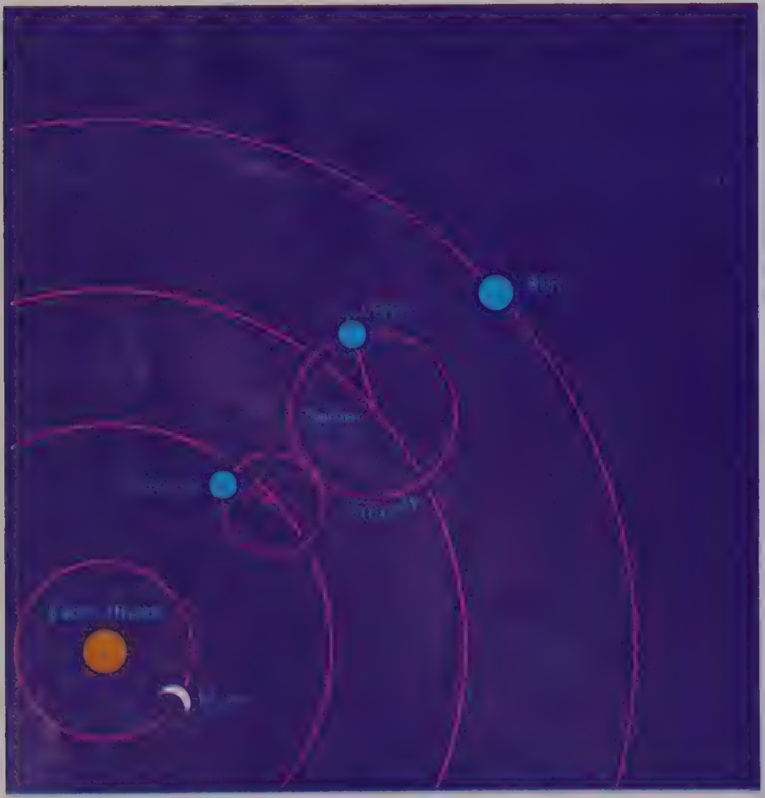
What happens to the shape of an ellipse as the two foci are brought closer and closer together?

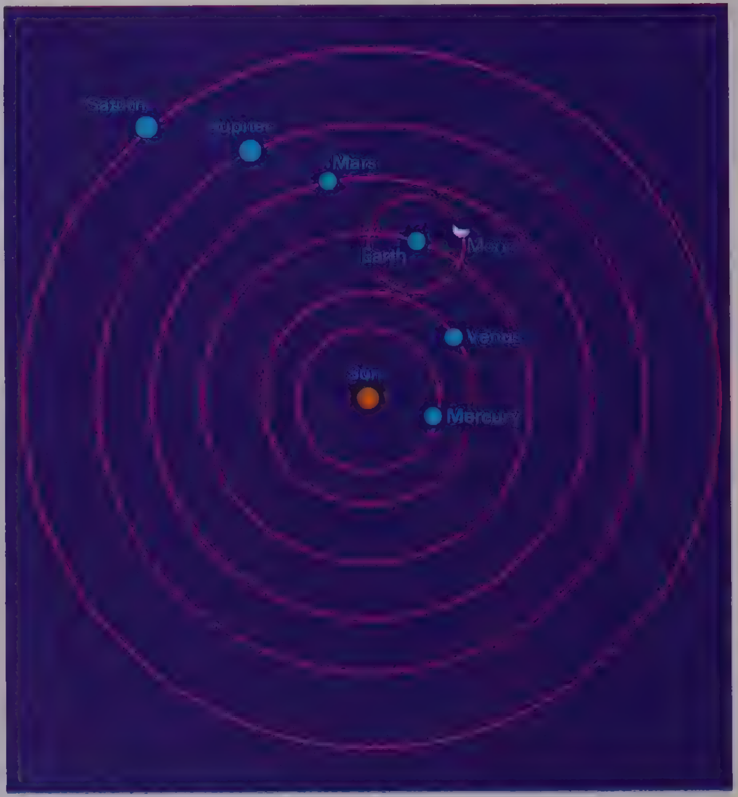
If the sun occupies one focus of the elliptical orbit of a planet, is the distance of a planet from the sun always the same?

Branching Out

It was stated in the text of this activity that Kepler formulated three laws concerning the motion of planets. You know the first law. What are the other two?

What is *retrograde motion?*





Does the moon have retrograde motion?

Related to the elliptical orbit of a planet, what is the meaning of *perihelion* and *aphelion?*

Do planets travel at a constant speed in their orbits around the sun?

An ellipse which is long and narrow represents the orbit of one of the sun's family. Which member has a flattened elliptical orbit? Hint: draw such an orbit and read Activity 4 of this chapter.

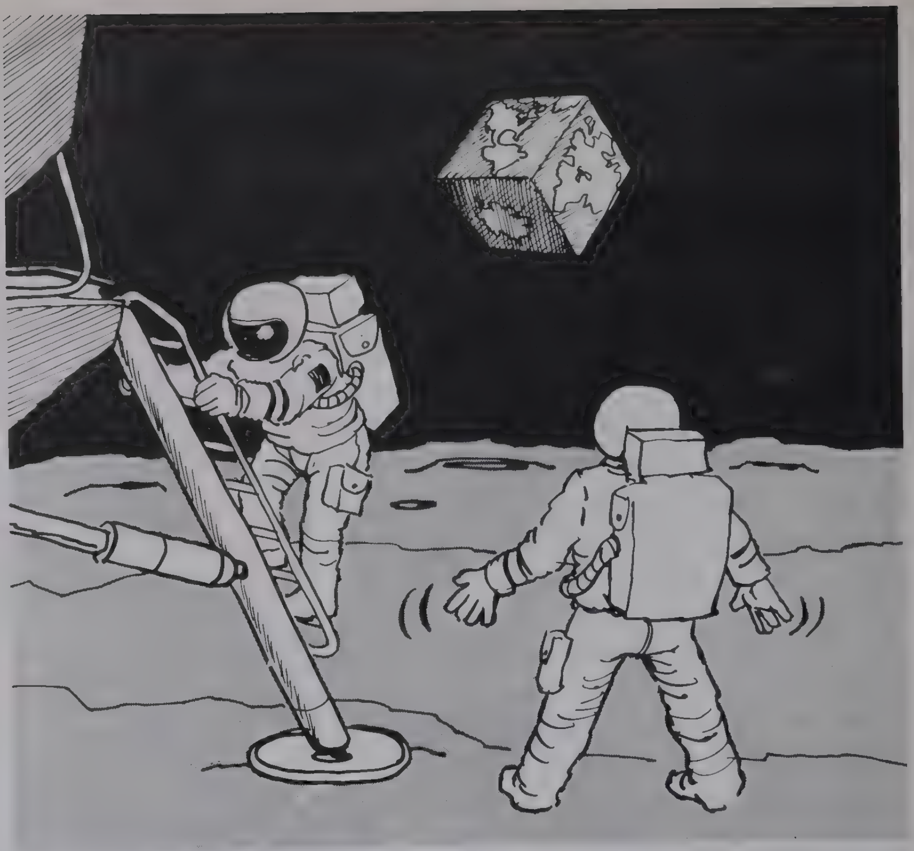
What do the terms *heliocentric* and *geocentric* mean?

In the table on page 77, a column is labelled *average distance from the sun.* Astronomers calculate a planet's average distance from the sun in the following manner. When a planet is closest to the sun in its elliptical orbit it is at its perihelion. When it is at its farthest from the sun, it is at its aphelion. For example, when the earth reaches its perihelion it is 147 250 000 km from the sun, and at its aphelion it is 152 000 000 km from the sun. To find the average distance from the sun add these two distances together and divide by two. What is the average distance of the earth from the sun?

Using the following information, calculate the average distance of Mercury from the sun. At its perihelion Mercury is 45 900 000 km from the sun; at its aphelion it is 70 000 000 km from the sun. Complete the following table using books on astronomy or an encyclopedia.

Facts about the Sun, its Family and the Moon

Name	Average Distance from Sun	Diameter	Period of Revolution	Period of Rotation	Number of Satellites
Sun					
Mercury					
Venus					
Earth					
Mars					
Asteroids (Ceres)					
Jupiter					
Saturn					
Uranus					
Neptune					
Pluto					
Moon					



Using the data about each of the following famous astronomers construct a date line. Draw a line, marking off in equal units the years from 1470 to 1640 and then, using a different color for each man, shade in his life span on the date line. How many of them actually lived at the same time?

Copernicus:	1473 to 1543
Tycho Brahe:	1546 to 1601
Galileo:	1564 to 1642
Kepler:	1571 to 1630

What was Galileo's full name?

What is Barnard's Star? Why is it of great interest to today's astronomers?

What are the ancient symbols for each of the planets?

Activity 2:

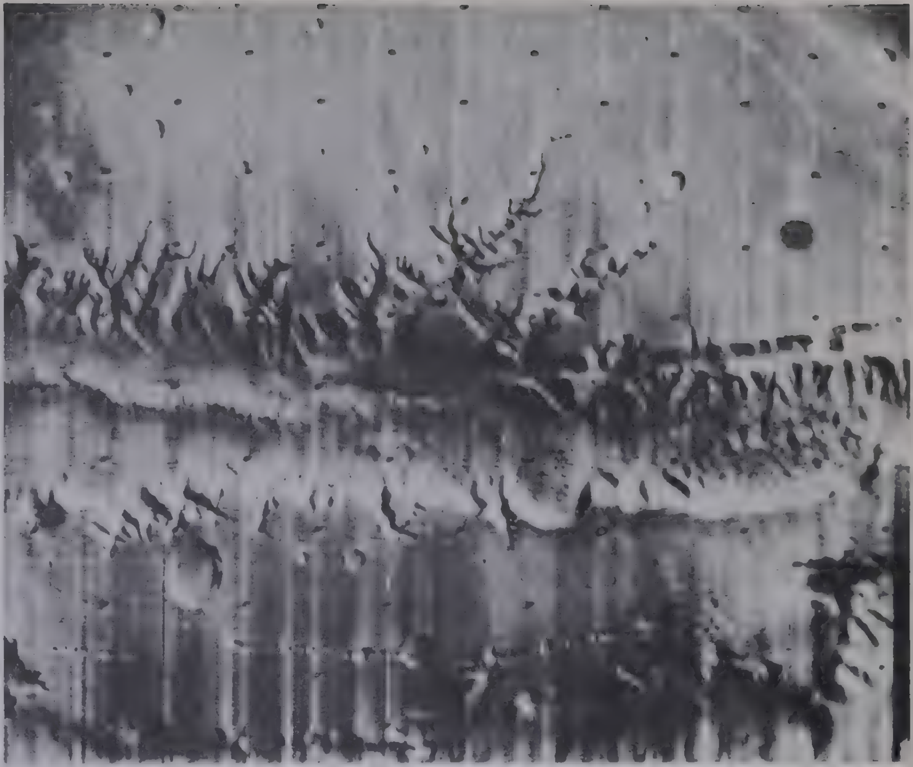
How can the position of the visible planets – Mercury, Venus, Mars, Jupiter, and Saturn – be located?

Very early in his stargazing activities man discovered that some of the brighter points of light or stars he saw in the sky, moved among the other stars. These steadily moving stars were termed wandering stars or planets by the ancient Greeks. Although man has known about the existence of planets for centuries he has not yet succeeded in visiting one. In November 1971, the space ship Mariner IX approached and went into orbit around the planet Mars, taking pictures of it. Huge dust storms covering the surface of the planet Mars produced fuzzy pictures of its surface features at first.

BRAHER
BILLER
RVDER
LANDER
LONGER
ROSENKRANS
TROLLER
ROSENSPA
ON HABERI
SED ESSE
EFFIGIES TYCHONIS BRAHE OTTONIDIS DANI
DÑI DE KNVDSTRVP ET ARCIS VRANIENBVRG IN
INSVLA HELLISPONTI DANICI HVENNA FVNDATORIS
INSTRVMENTORVMQ: ASTRONOMICORVM IN EADEM
DISPOSITORVM INVENTORIS ET STRVCTORIS
ÆTATIS SVÆ ANNO 40. ANNO DÑI.1586.COMPL.

Tycho Brahe had to have a silver nose made for himself. Why?

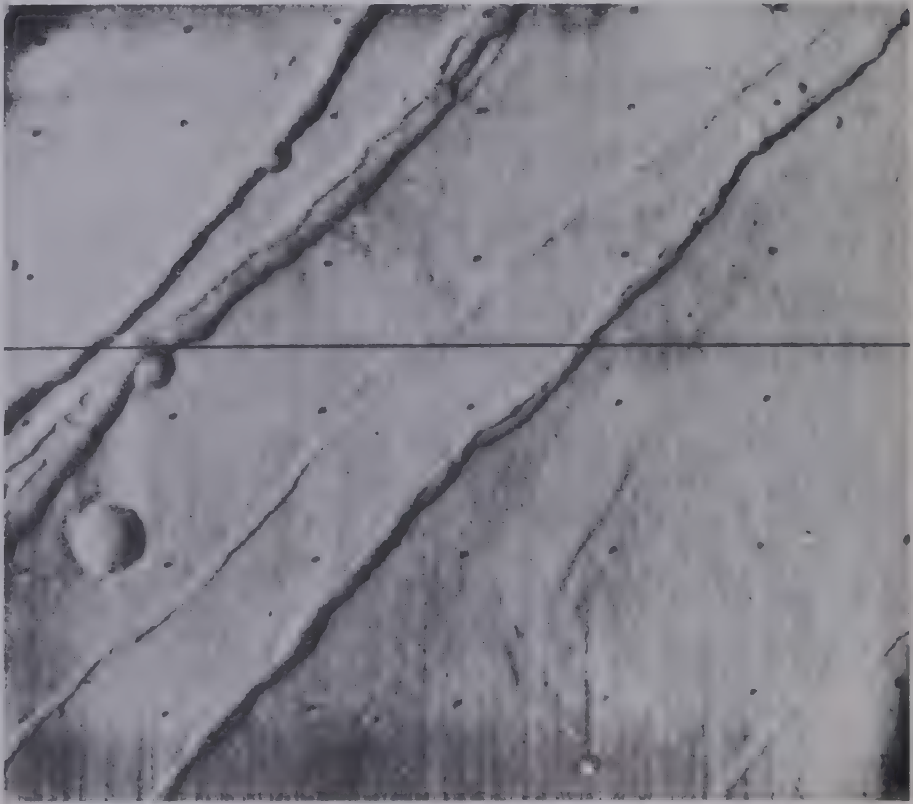
View of Mars taken by Mariner 9. A vast chasm with branching canyons 480 km *south of the equator.*



Later in its orbit Mariner IX obtained clear and fascinating photographs of Mars.

The visible planets are always found in or near a narrow band in the sky called the zodiac. This happens because the planets revolve around the sun on nearly the same plane as the sun. By knowing where and when to look for this planetary highway in the sky, called the zodiac, the position of the planets can be discovered. The following star chart and tables will allow you to locate the planets through the years 1971 to 1976.

The star chart has a blue, wavy line representing the ecliptic or path of the planets among the stars. The line starts at 0° and goes to 360° and this equals one complete turn of the starry sphere. The line is divided into 10° sections for ease in locating an object anywhere along the ecliptic. When using the star chart to locate the constellations indicated on it, go out of doors, face south, and hold the chart at a 45° angle above the horizon. Your own star chart which you constructed in Chapter 2 will assist you greatly in locating any constellation once you have determined in which constellation a particular planet is to be found.



The first clear view of rilles, or cracks, in the Martian crust.

The tables must be used in conjunction with the star chart showing the ecliptic, because the tables give you the position of the planet in degrees along the ecliptic. All positions indicated in the tables are approximately for the middle of each month between 21:00 and 24:00 except when coded as being in the morning sky.

The blue numerals indicate that the planet is visible only in the morning sky while the red numerals mean that the planets can be seen in the evening sky.

To actually find a planet for any given time, search for the present year and month in the tables. For example, suppose you wanted to know the position of Jupiter in October 1973. First locate the 1973 table, then run your finger down the column under the heading, ''Jupiter'', until it is opposite the month of October. Your finger should be pointing to the numeral 305 which is really 305° on the ecliptic. This point is in the position of the constellation Capricorn.

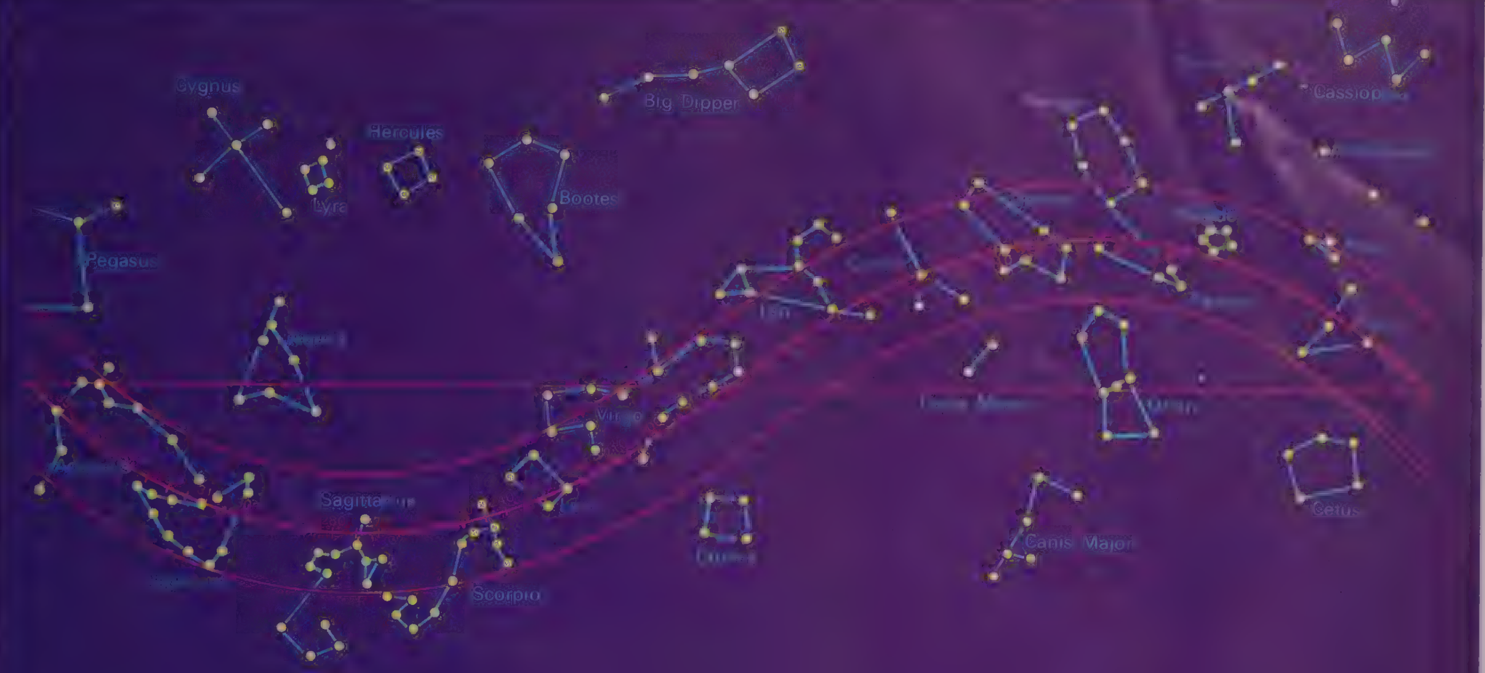
Since the tables give the position of each planet for the middle of the month against a particular background of stars you would have to look to the west (the right) of the numeral on the ecliptic to locate the position earlier in the month. Similarly you would have to look to the east (the left) of the numeral to locate the position later in the month.

Should you wish to know the position of the planets beyond 1976, you could write to your nearest science museum or planetarium or search through books regarding the planets at your local library to obtain the information you require. If you encounter any tables beyond 1976 with blank spaces in them, it simply means that a particular planet is too close to the sun to be seen. Mercury tends to fall into this category more often than the other planets. Mercury is seen only for very short periods of time just after sunset and just before sunrise.

The Royal Astronomical Society of Canada publishes a yearly *Observer's Handbook*. It gives the positions of the planets as well as other current information about astronomy. The *Observer's Handbook* can be obtained from:

Royal Astronomical Society of Canada
252 College Street
Toronto, Ontario.

for approximately $2.00.



1973

	Mercury	[illegible]	*Mars*	*Jupiter*	*Saturn*
JANUARY	[illegible]	[illegible]	247	[illegible]	73
FEBRUARY	338	[illegible]	274	[illegible]	72
MARCH	353	[illegible]	[illegible]	[illegible]	73
APRIL	[illegible]	77	[illegible]	[illegible]	76
MAY	[illegible]	[illegible]	[illegible]	[illegible]	79
JUNE	[illegible]	100	[illegible]	[illegible]	82
JULY	[illegible]	138	[illegible]	[illegible]	[illegible]
AUGUST	[illegible]	174	[illegible]	[illegible]	[illegible]
SEPTEMBER	[illegible]	207	[illegible]	[illegible]	
OCTOBER	[illegible]	242	[illegible]	[illegible]	
NOVEMBER	[illegible]	278	[illegible]	[illegible]	
DECEMBER	[illegible]	306	[illegible]	[illegible]	

1975

	Mercury	*Venus*	*Mars*	*Jupiter*	*Saturn*
JANUARY	310	[illegible]	[illegible]	347	106
FEBRUARY	[illegible]	[illegible]	[illegible]	353	104
MARCH	[illegible]	20	[illegible]	359	103
APRIL	[illegible]	56	[illegible]	[illegible]	104
MAY	[illegible]	94	[illegible]	[illegible]	106
JUNE	[illegible]	130	[illegible]	[illegible]	110
JULY	[illegible]	154	[illegible]	[illegible]	114
AUGUST	154	160	[illegible]	[illegible]	[illegible]
SEPTEMBER	194	[illegible]	[illegible]	[illegible]	[illegible]
OCTOBER	[illegible]	[illegible]		19	[illegible]
NOVEMBER	[illegible]	[illegible]	[illegible]	15	[illegible]
DECEMBER	268	[illegible]	[illegible]	14	[illegible]

1974

	Mercury	*Venus*	[illegible]	*Jupiter*	*Saturn*
JANUARY	297	[illegible]	[illegible]	320	90
FEBRUARY	342	[illegible]	[illegible]	327	88
MARCH	[illegible]	[illegible]	[illegible]	[illegible]	88
APRIL		[illegible]	[illegible]	[illegible]	89
MAY	[illegible]	[illegible]	[illegible]	[illegible]	93
JUNE	[illegible]	[illegible]	[illegible]	[illegible]	97
JULY	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
AUGUST	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SEPTEMBER	[illegible]	[illegible]	[illegible]	344	
OCTOBER	[illegible]		[illegible]	341	
NOVEMBER	[illegible]	[illegible]	[illegible]	340	[illegible]
DECEMBER	[illegible]	[illegible]	[illegible]	342	[illegible]

1976

	Mercury	*Venus*	[illegible]	*Jupiter*	*Saturn*
JANUARY	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FEBRUARY	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MARCH	[illegible]	[illegible]	[illegible]	[illegible]	118
APRIL	33		[illegible]	[illegible]	118
MAY	[illegible]	[illegible]	[illegible]	[illegible]	120
JUNE	[illegible]	[illegible]	[illegible]	[illegible]	123
JULY	[illegible]	[illegible]	[illegible]		127
AUGUST	166	[illegible]	[illegible]		[illegible]
SEPTEMBER	185	[illegible]	[illegible]		[illegible]
OCTOBER	[illegible]	[illegible]	[illegible]		[illegible]
NOVEMBER	[illegible]	[illegible]			[illegible]
DECEMBER	[illegible]				[illegible]

Digging Deeper

What does the straight line running through the center of this star chart represent?

Why do the tables include only five of the planets?

Survey the tables to discover whether the planets are more visible in the predawn or in the evening sky. How could your star chart aid you in this activity?

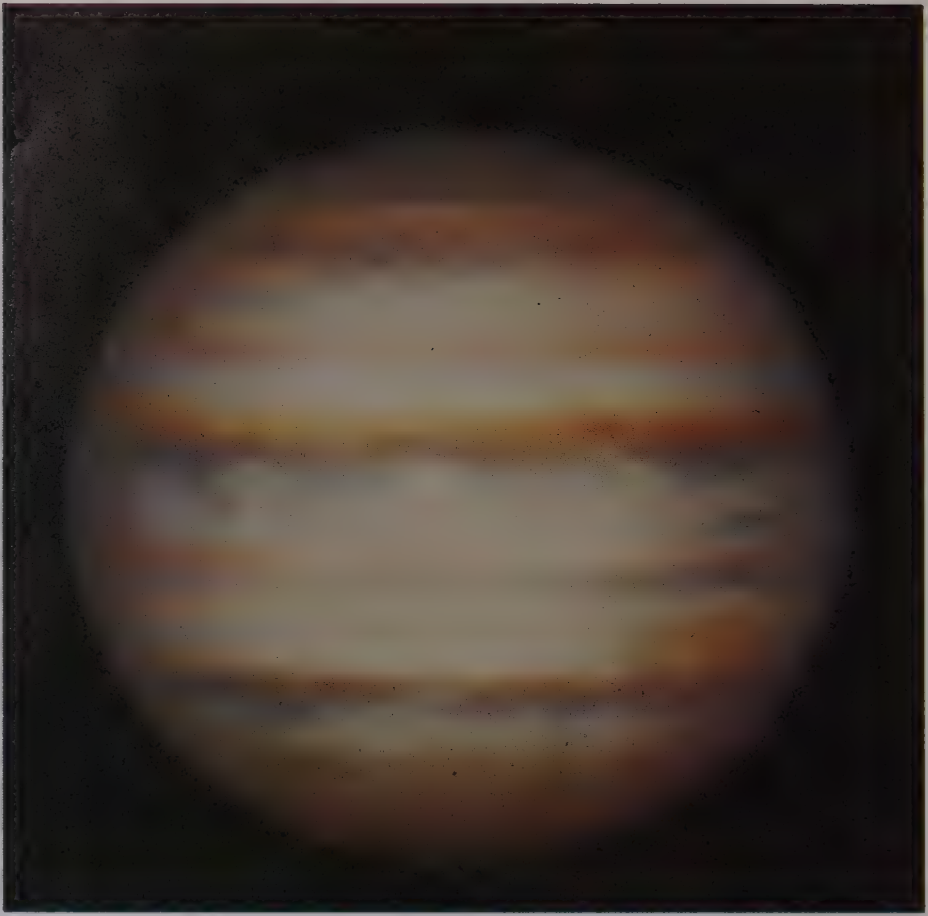
Branching Out

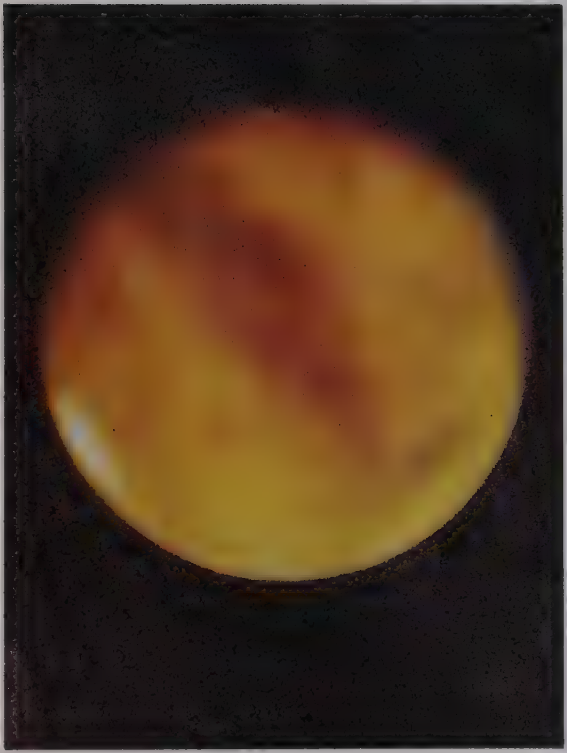
How wide is the zodiac in degrees? Gravity is a force (or pull) which at-

Jupiter

Mars

Saturn





tracts objects toward the center of the earth. All bodies, even planets and stars in the universe, are affected by gravity. By lifting objects you can "feel" the force of gravity pulling downwards on the object. All 1 kg masses on the earth experience a force of gravity of about 10 N. To find out your force of gravity on the other planets complete the following table.

What is an *evening star?* a *morning star?* In any one year how long are these stars visible in either the morning or evening?

Why are they called stars?

What are some of the differences between a star and a planet? List the differences in a chart under the headings "Star" and "Planet".

Observe each of the planets mentioned in the tables and write down the color of the light that shines.

Keep track of the planet Jupiter for several weeks, noting the background of stars through which it passes each night. Does Jupiter move east or west across the sky?

FIND THE FORCE YOUR MASS WILL EXERT ON THE SUN, MOON AND PLANETS

Celestial Body	Your Mass on Earth (kg)	×	Force of Gravity (N/kg)	=	Force exerted by your Mass on the Celestial Body (N)
Earth		×	9.80 N/kg	=	
Mercury		×	3.7 N/kg	=	
Venus		×	8.6 N/kg	=	
Mars		×	3.8 N/kg	=	
Jupiter		×	23.4 N/kg	=	
Saturn		×	11.47 N/kg	=	
Uranus		×	9.02 N/kg	=	
Neptune		×	12.05 N/kg	=	
Pluto		×	1.47 N/kg	=	
Sun		×	274.4 N/kg	=	
Earth's Moon		×	1.6 N/kg	=	

What are *asteroids?* How many asteroids have been charted to date? What is their origin? How large is the largest asteroid?

How can four of Jupiter's moons be studied? For this activity you will need your telescope or a good pair of binoculars and a chart similar to the one illustrated. Place a circle to represent Jupiter in the center of each section of the chart. When Jupiter is visible in the sky, go out of doors and observe it with a telescope or binoculars. Note the position of Jupiter's four brightest moons and then mark them on the chart on either side of the circle.

Indicate the brightest moon with a larger dot. Continue to do this at the same time each night for two weeks. Are all of these four moons visible all the time? If not, why not? Which moon travels fastest? slowest? What are the names of these four moons? Are they all the same size? Try to predict where the moons will be next.

Date	Position of the Moons of Jupiter
Aug. 3, 1972	• • ◯ ∘ •
4	◯
5	◯
6	◯
7	◯
8	◯
9	◯
10	◯
11	◯
12	◯
13	◯
14	◯
15	◯

Activity 3: How can meteors be charted?

Have you ever heard of a shooting star? Most people have seen streaks of light shooting across the sky and exclaimed, "Look, a shooting star!" What they really are seeing is a meteoroid hitting our atmosphere and burning up.

The average speed of a meteoroid is about 137 000 km/h. When meteoroids enter our atmosphere, they are called meteors. These meteors are visible for a few seconds, and then burn up and disappear about 65 km from the surface of the earth. Scientists believe that millions of these meteoric particles of stone and metal enter the earth's atmosphere daily and disintegrate into dust which filters down to the ground. It is estimated that approximately 2 t of meteoric dust fall on the earth every 24 h.

Meteors or meteor showers can be recorded on a star chart. Pick a clear, dark, moonless night and watch the sky for "shooting stars". Usually three or four can be seen in an hour. The best time for meteor-watching is after midnight. When a meteor is spotted, note the constellation it was sighted in and record the information on a chart similar to the one illustrated. Your star-finder chart will help you in identifying the constellations. Do this for several nights and keep a record of it. If you wish to do a more professional job with your meteor-watching, write:

American Meteor Society
University of Pennsylvania
Department of Astronomy
Philadelphia, Pennsylvania 19104,

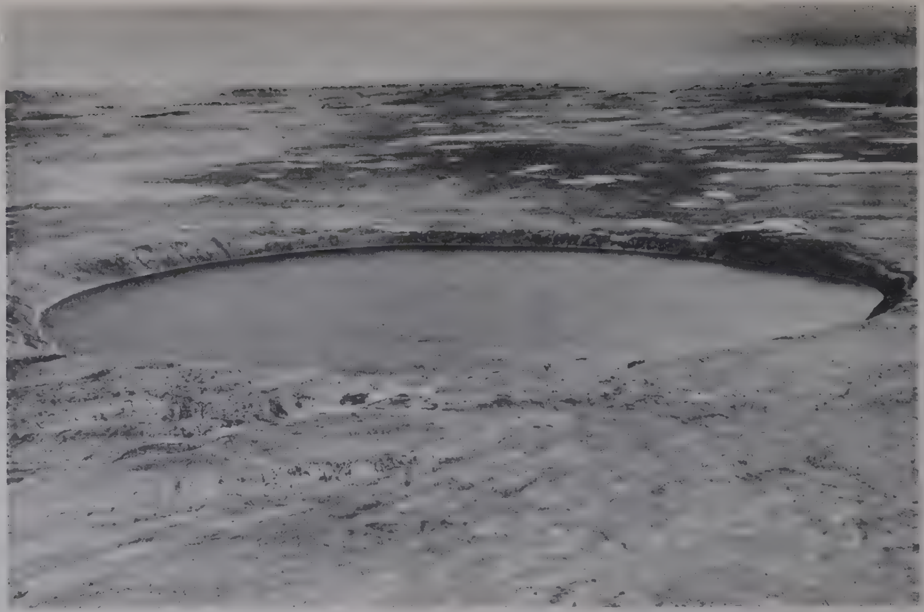
for directions on making reports of your sightings.

For help in selecting ideal times to watch meteor showers see the table on page 87. This table will furnish you with information such as the name of the shower, date that it will be strongest, and the approximate number per hour. Refer to the chart on page 87 for annual showers.

Record Chart for Meteors Sighted

Date	Time	Number	Constellation

Comet Humason (1961e)



Meteor crater in Quebec's Ungava Peninsula.

Digging Deeper

Do meteors recorded on your chart seem to originate in any particular constellation?

What is a *meteorite?*

What is a *meteoroid?*

What is a *sporadic meteor?*

What is a *bolide?*

What is a *shower meteor?*

What is the difference between a sporadic meteor and shower meteor?

Are all meteors the same size, shape, and composition?

Meteorites are classified into three groups according to the most common substance found in them. What are the three classifications?

What are the six most common substances found in meteorites?

What are *Widmanstaetten lines?*

What is a *fireball?*

It was mentioned in Activity 3 that meteor dust adds about 2 t to the earth's surface daily. Most of the dust is composed of iron and nickel. Since both of these substances are magnetic, they can be recovered by dragging a small magnet over the ground. About ten per cent of the material clinging to the magnet will be dust from outer space. Examine some of it under a low-powered microscope if one is available.

Map the particular part of the sky you are watching for meteors. If you are observing the southern part of the sky include the southern sky constellations. When a meteor is sighted, draw a line on the map to indicate the path of the meteor across the sky. Then extend the line in the other direction to determine the origin of the meteor in space.

Record as many meteors as possible during the same night. Once several lines have been drawn on the map study your results. Is there any pattern? Do meteors occur in all parts of the sky? What is a radiant?

PEANUTS® **By Charles M. Schulz**

PEANUTS
I AM ALWAYS IMPRESSED BY THE CONSTANCY OF THE STARS..
IT GIVES ME A FEELING OF SECURITY TO LOOK UP AND KNOW THAT THE STAR I SEE WILL ALWAYS BE THERE, AND WILL...
5-2

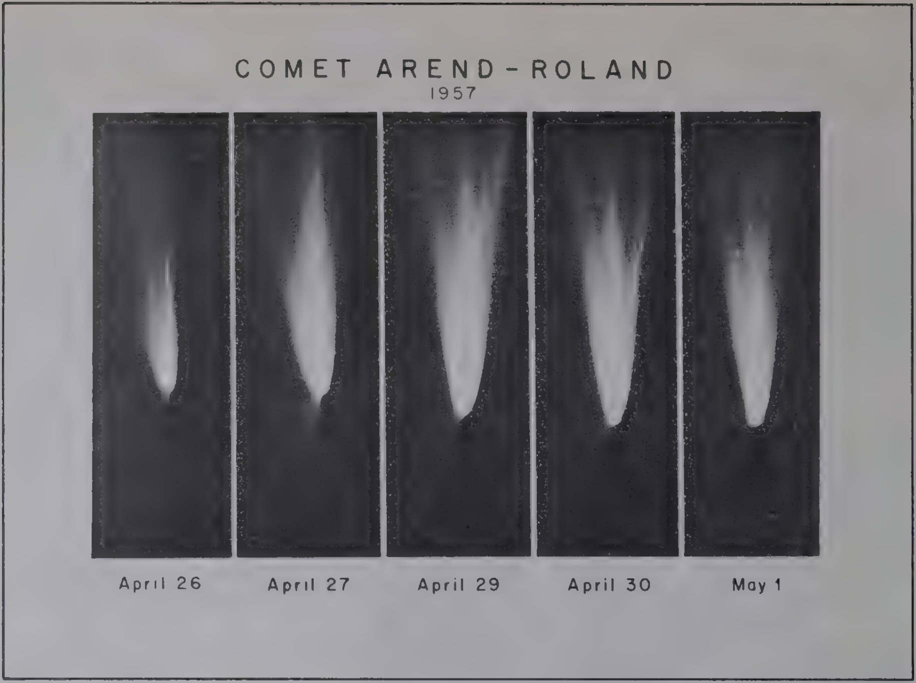
Meteor showers are named according to the constellation out of which they radiate. Meteors radiating or coming from the constellation Leo are termed Leonids; those from Orion are termed Orionids. The following table lists the main annual meteor showers for the date of maximum shower activity.

Which constellation provides the best display of meteor showers according to the table provided?

TABLE OF THE MAIN ANNUAL METEOR SHOWERS

Name of Shower	Number of Days it will last	Date of maximum activity	Hours of maximum activity	Approximate number of meteors per hour
Quadrantids	4	January 3	24:00 - 04:00	28
Lyrids	4	April 22	24:00 - 04:00	7
Eta Aquarids	8	May 5	24:00 04:00	7
Pons-Winnecke	?	June 29	24:00 - 04:00	?
Delta Aquarius	3	July 29	24:00 - 04.00	27
Perseids	25	August 12	24:00 04:00	69
Draconids	1	October 10	24:00 04:00	?
Orionids	14	October 20	24:00 04:00	21
Leonids	7	November 17	24:00 [illegible]	23
Andromedids		November 21	[illegible]	?
Geminids	14	December 13	[illegible]	23

Comet. Arend-Roland, 1957.

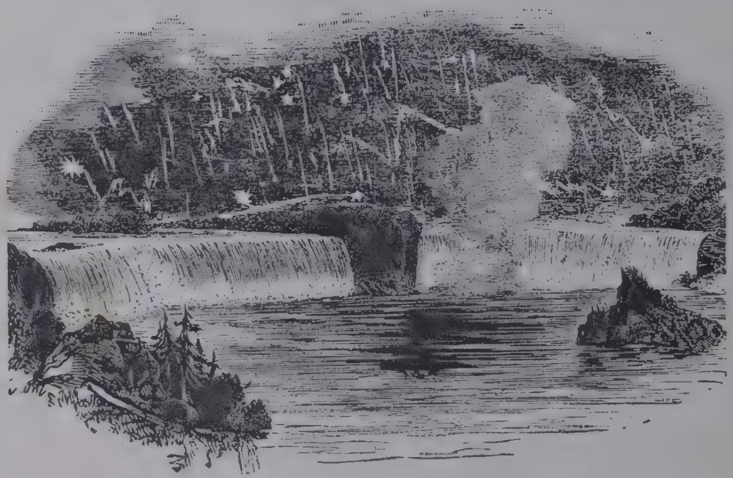


Activity 4:

What are comets?

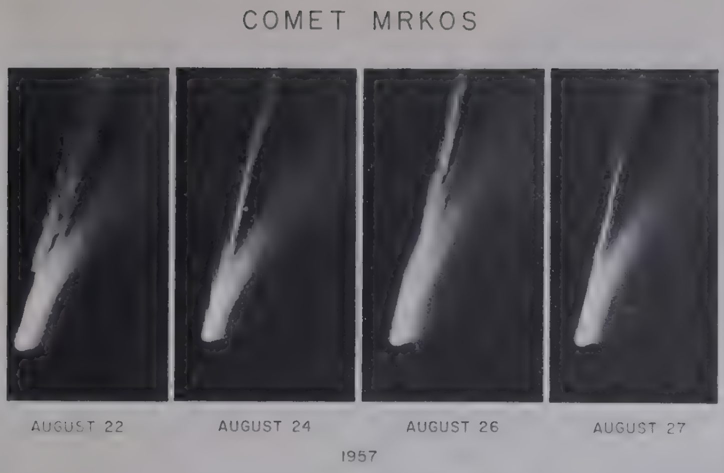
One of the most interesting and strangest members of the sun's family is the comet. It is the ghost of the solar system — silent, slow-moving, ever-changing — a long, wispy specter in the inky blackness of outer space. Comets can be large or small. Some of the larger ones stretch out for more than 320 000 000 km and have diameters larger than the sun itself. There are believed to be millions of comets in the solar system, each with its own large, flattened orbit around the sun.

Examine the following set of comet pictures. The pictures themselves will not really tell you what a comet is, but, if you also use research books and articles on comets and answer the questions in the Digging Deeper section, a fairly good reply to the question, *What are comets?*, should result.



Bottom left: Head of Halley's Comet.

Bottom right: Ikeya - Seki, 1965.



Photographed with the 120 cm schmidt telescope

Top left: Comet Mrkos, 1957.

Bottom left: Comet Ikeya, 1963.

Top right: Comet Cunningham.

Bottom right: Ikeya - Seki, over Hawaii.

Digging Deeper

Why are comets referred to as the ghosts of the solar system?

Are all comets the same size and shape?

Which of the comets shown is the most famous one? Why?

What shape is the orbit of a comet around the sun?

Branching Out

Where do comets come from in outer space?

Something very strange happens to a comet if it is pulled into orbit around the sun, especially as it is drawn closer to the sun. What happens to a comet as it nears the sun?

A comet usually has three distinct parts to it: what are they?

Do all comets have tails?

Comets have sometimes been referred to as ''dirty snow balls''. Why might this be an excellent name for them?

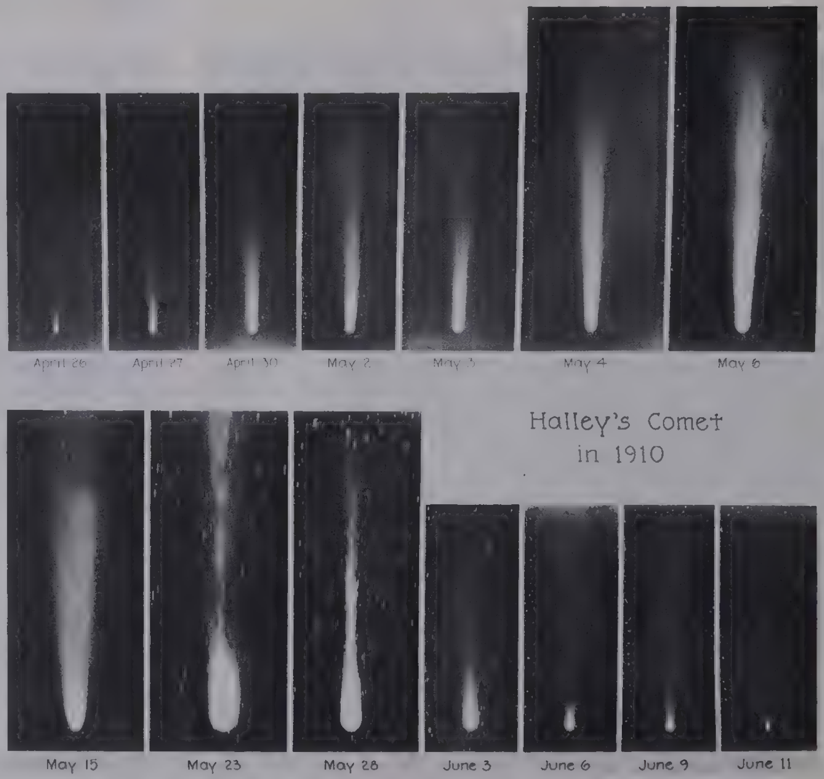
What substances or elements are found in comets?

Does a comet produce its own light?

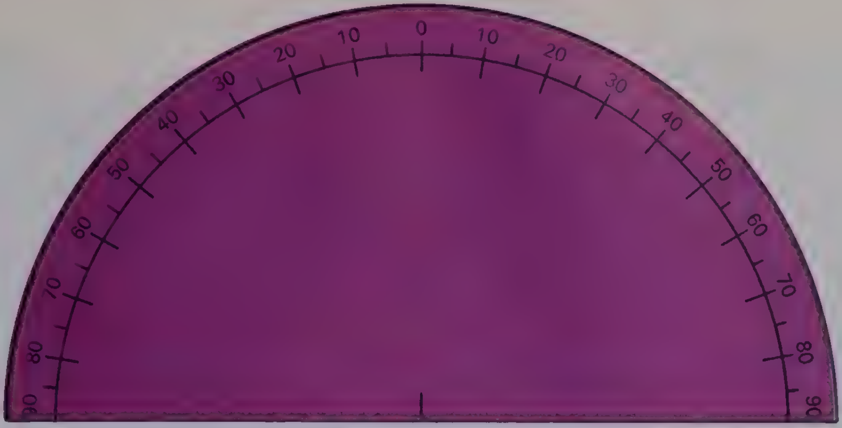
What is a *comet gravel bank* and how is it related to meteors?

Using the drawing board from Activity 1 of this chapter and the other materials necessary to draw an ellipse, draw the long, flattened orbit of a comet.

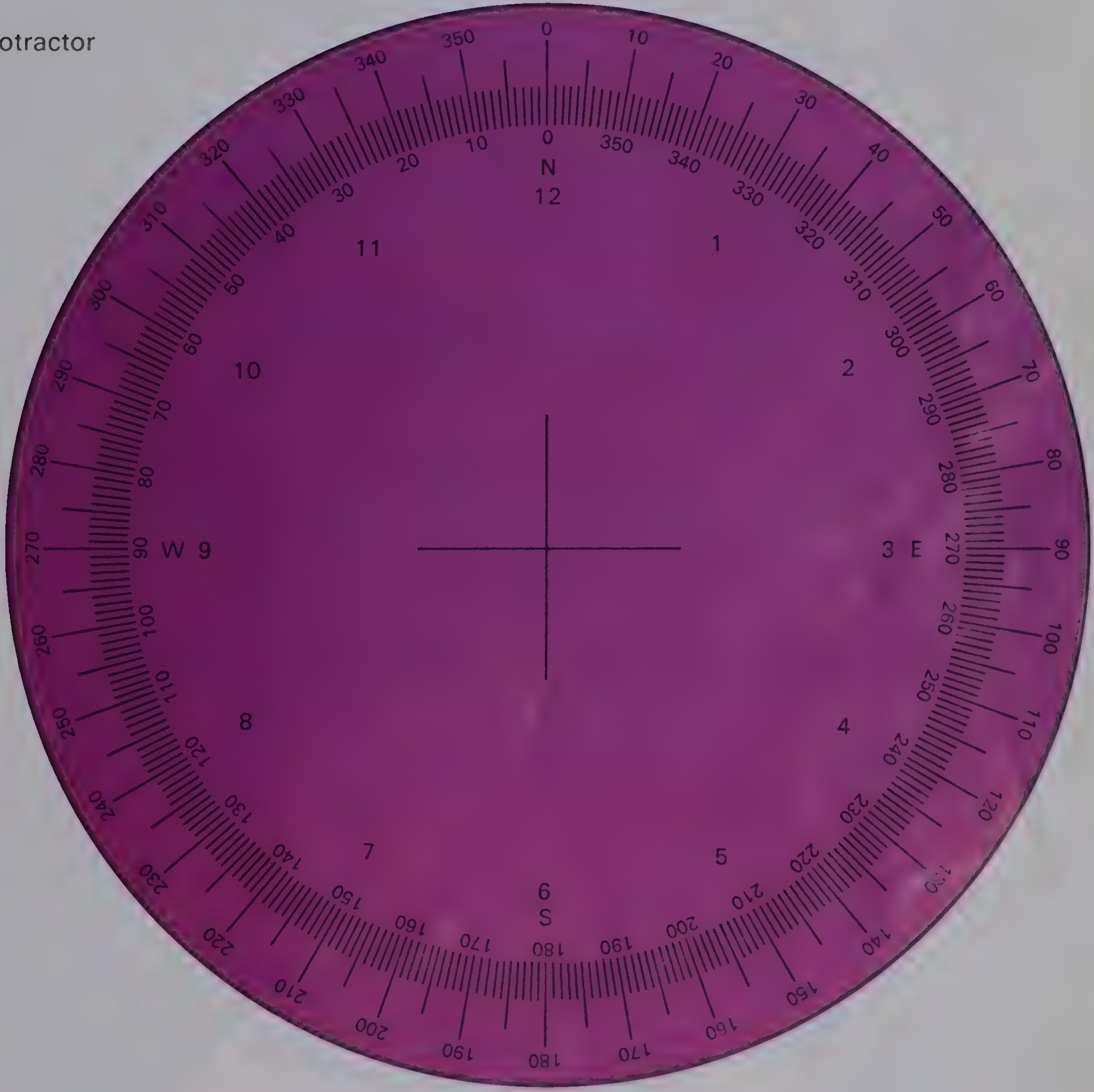
The most famous comet is Halley's Comet. Read in books to discover why this particular comet is so well-known. How did Halley's Comet affect the earth in 1910? When is this comet expected to pass by the earth again?

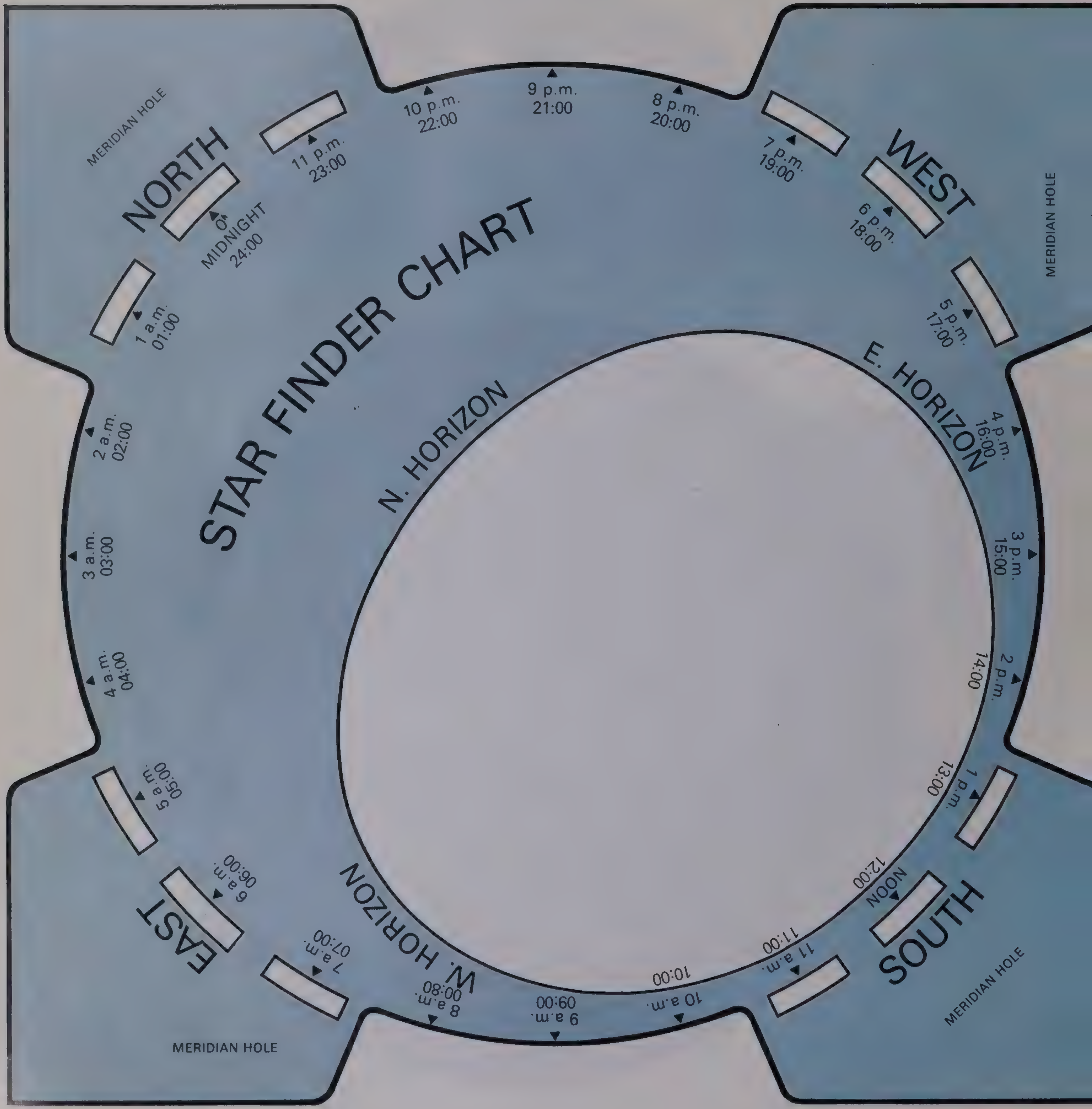

Halley's Comet in 1910

Template I
Half Circle Protractor



Template II
Full Circle Protractor




STAR FINDER CHART
NORTH
WEST
EAST
SOUTH
N. HORIZON
E. HORIZON
W. HORIZON
MERIDIAN HOLE
MERIDIAN HOLE
MERIDIAN HOLE
MERIDIAN HOLE
0 or MIDNIGHT 24:00
1 a.m. 01:00
2 a.m. 02:00
3 a.m. 03:00
4 a.m. 04:00
5 a.m. 05:00
6 a.m. 06:00
7 a.m. 07:00
8 a.m. 08:00
9 a.m. 09:00
10 a.m. 10:00
11 a.m. 11:00
NOON 12:00
1 p.m. 13:00
2 p.m. 14:00
3 p.m. 15:00
4 p.m. 16:00
5 p.m. 17:00
6 p.m. 18:00
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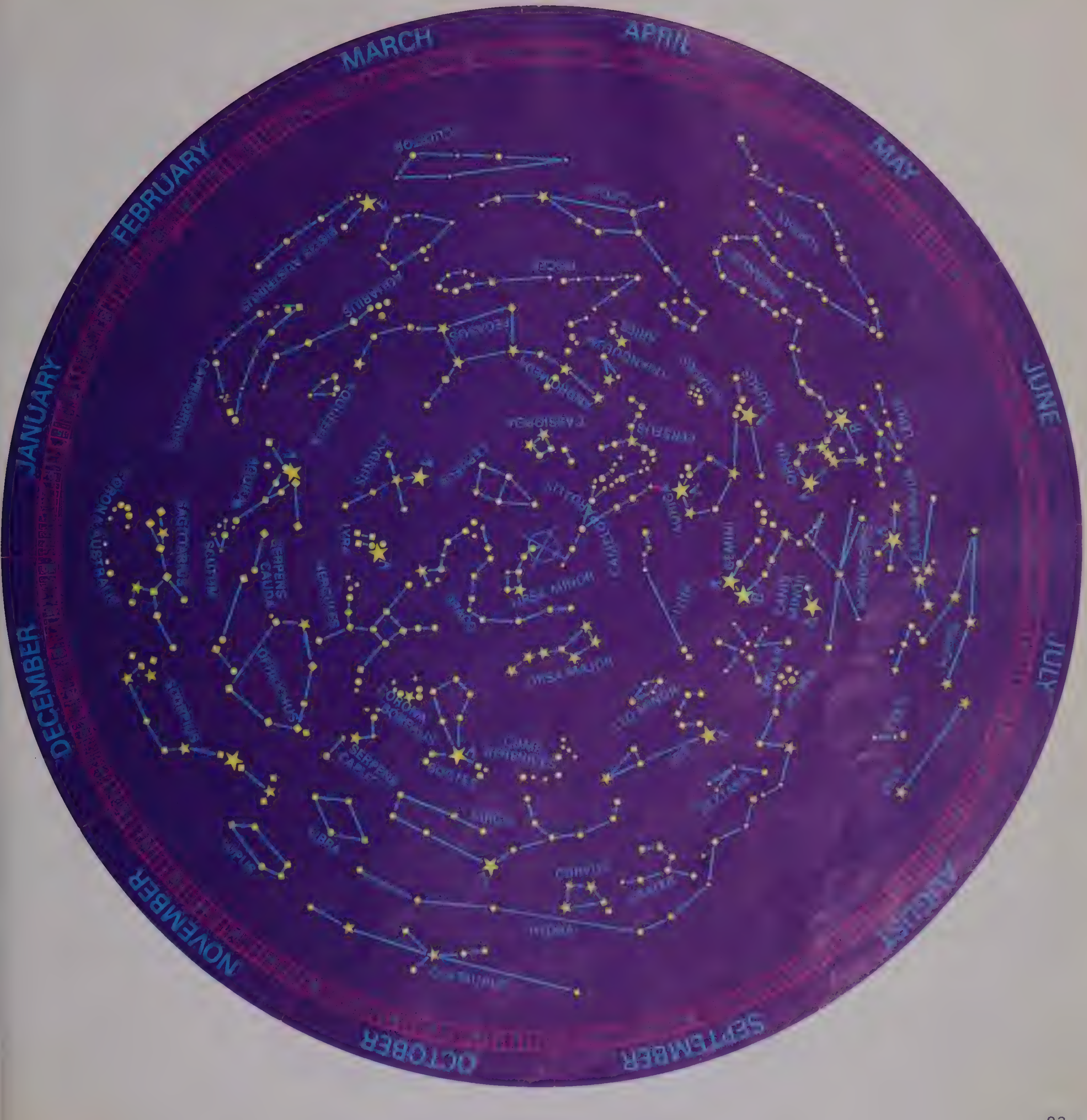
9 p.m. 21:00
10 p.m. 22:00
11 p.m. 23:00


MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
CASSIOPEIA
PEGASUS
ANDROMEDA
AQUARIUS
CAPRICORNUS
LYRA
HERCULES
SERPENS CAUDA
OPHIUCHUS
SAGITTARIUS
SCUTUM
CORONA AUSTRALIS
SCORPIUS
LIBRA
LUPUS
VIRGO
CORVUS
HYDRA
CENTAURUS
URSA MINOR
URSA MAJOR
CORONA BOREALIS
BOOTES
SERPENS CAPUT
COMA BERENICES
LEO MINOR
GEMINI
CANIS MINOR
AURIGA
PERSEUS
ORION
CAMELOPARDALIS

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Through the text and pictures, the reader is familiarized with the use of the telescope in viewing the skies.

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Covers the wide scope of astronomy – from ancient beliefs to modern theories on life on other planets. Well-indexed for specific references.

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Bibliography prepared by Evelyn L. Olejnik.

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